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**Main Topic :** A vision for the 21st century in Mediterranean Countries

For the past seven years, ATW has been the recognized source of applied collaboration between academia and industry. Last year 's workshop concluded with to one important decision ; the lack of a development model for countries belonging to the Mediterranean basin leads the members of ATW to propose for this year the following topic : a vision for the 21st century in Mediterranean countries. This year's topic will focus again on new technology application, economic development, but also on interculturality and communication in order to take into account a coherent vision for the next century.
The workshop will include several panel discussions, working group sessions and technical presentations. The presentations will be published in the 7th ATW proceedings.
Three keynotes speakers, one from the US government (the US AIR FORCE Deputy assistant) one from an International Institution (the UNESCO Egyptian Representative) and one from the SECUM (Sciences, Education et Cultures en Méditerranée) , will actively participate in the whole workshop.
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# Validation of Behavioral VHDL Descriptions Using Software Engineering Concepts

Christophe Paoli - Jean-François Santucci

*SDEM – Systèmes Dynamiques, Energétiques et Mécaniques, URA CNRS 2053, Université de Corse, BP 52 Quartier Grossetti ; 20250 Corté France*
*{cpaoli, santucci}@univ-corse.fr*

**Abstract.** This paper deals with validation of VHDL descriptions at the early phase of the design of a digital system. Our approach consists in generating test data from a given VHDL behavioral description. The validation is achieved by comparing the results obtained using the simulation of the VHDL description within the test data and the results which should have been obtained from the specification of the system to be designed. In this paper we propose an original approach based on software testing concepts.

## I. Introduction

We propose in this paper an original approach based on software testing concepts[1] in order to validate behavioral VHDL[2] descriptions. We choose such an approach because a VHDL description is a software program describing the behavior of a digital system. The problem is to generate test data using software engineering concepts. Generating test data points out the resolution of three basic problems : (i) it is necessary to define the number of test data to be considered (this number is called the length of the test data in the following) ; (ii) it is necessary to define criteria which express the "quality" requirements that the test data have to fulfill ; (iii) it is necessary to define an algorithm allowing to generate test data. To solve these problems we are concerned with testing techniques developed in the field of software engineering[1]. This interest is motivated by the fact that behavioral hardware languages such as VHDL and conventional languages such as C or ADA[3,4] are supported by common concepts. Having selected criteria from the field of software testing allowing the three aforementioned problems to be solved, we are in the phase of studying how such criteria could be measured and applied to VHDL behavioral descriptions. In order to find criteria which could estimate the length of test data and express the quality of test data, we have been concerned with two kinds of techniques: (i) the computation of cyclomatic complexity metric (McCabe metrics[4]) and (ii) the application of coverage-based metrics[1]. The generation of test data is based on a powerful algorithm[5] issued from software testing methods : this algorithm allows to calculate the minimum number of control flow paths which are sufficient for the generation of all possible execution paths involved in a VHDL description. The McCabe metric and the previous algorithm are based on a graphical representation of the control part of the software being tested. McCabe defined a cyclomatic number of a graph associated with the control part of software. This number represents the number of linearly independent paths of the graph. He proved that the cyclomatic number represents the minimum number of test data to be generated in order to test the control part of software. In order to evaluate the quality of test data, conventional software testing criteria are used. These criteria correspond to coverage based metrics[6].

The first part of the paper will deal with the graphical representation of the control flow graph (CFG) of a VHDL description we have chosen. We will present in detail in a second part the cyclomatic complexity concept and the coverage based criteria. This part will be illustrated by pedagogical examples. In the third part we will present the algorithm we select for generating the test data from a set of independent paths. In the last part we will present how these previous concepts are used in the case of VHDL descriptions. Furthermore we will give a brief overview of future work we envision to perform.

## II. Graphical Representation of Control Flows

In this part we briefly present how the control flow part of a VHDL description is modeled using graph concepts. These concepts are used : (i) to represent the sequencing of operations involved in a VHDL description and (ii) to point out the different execution paths. CFGs describe the structure of software modules. The definition of a module is language dependent. In general, it is a unit of code with an entry point and an exit point. Each CFG consists of nodes and edges. The nodes represent computational statements. Edges represent transfer of control between nodes. This graphical description helps to understand complex algorithms. The general structure and the CFG of a VHDL module is given in figure 1.

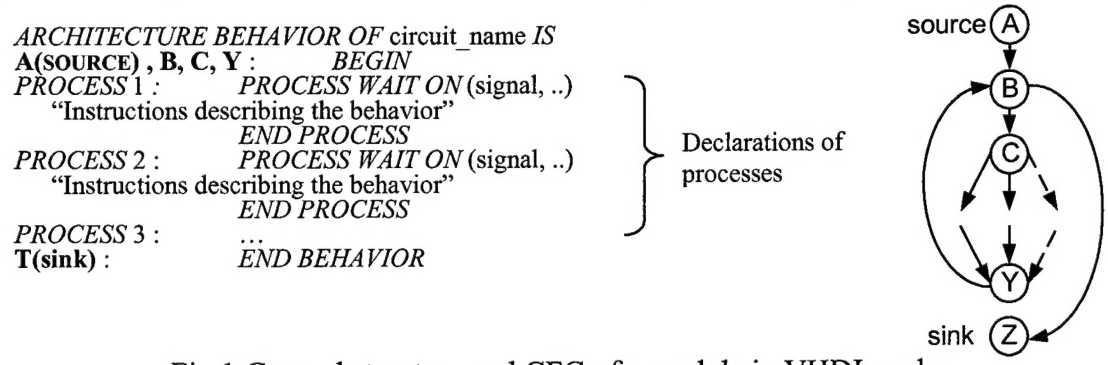



Fig 1 General structure and CFG of a module in VHDL code

A module is declared with the key word *ARCHITECTURE BEHAVIOR*. The processes involved in the behavioral description are executed in a concurrent way. The execution involves three kind of phases : (i) the scanning phase allowing to detect which processes are going to be activated ; (ii) the process activation allowing the execution of the statements belonging to the active processes ; (iii) the execution of the control structure (assignment, repetitive or selective) involved in the VHDL description of a given process. The key words *BEGIN* (A, B, C and Y nodes) and *END BEHAVIOR* (Z node) define the beginning and the end of a behavioral VHDL description. The A node is called the source node of the description. It has no incoming edge and only one outgoing edge which leads to the B node. The B node is used to model the scanning phase : (i) if at least one of the processes involved in the description is active then the following node in the execution path will be the C node ; (ii) in the contrary, the node which follows node B in the execution path is the Z node (see figure 1). The C node is the process distributor node. It allows to point out all the active processes. The number of outgoing edges of the C node is equal to the number of the processes in the description. The Y node is the process junction node. It represents the end of the execution of the active processes of the description. The number of incoming edges of the Y node is equal to the number of the processes in the description. The outgoing edge of this node always leads back to the B node. This outgoing edge allows to model the fact that the scanning phase is going to happen once again. The Z node is the sink node of the description and has no outgoing edge. Between the C and Y nodes, we find the nodes that correspond to the description of each individual process and that allow the modeling of the execution of the control structures (assignment, repetitive or selective) involved in the VHDL description of a given process. The figure 2 shows the control flow sub-graph of such control structures.

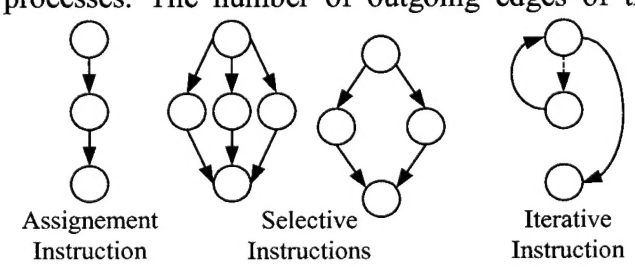



Fig 2 Control flow sub-graphs

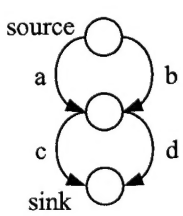
## *III. Cyclomatic Complexity and Structured Testing*

Cyclomatic complexity[7] measures the amount of decisions in a single software module. It is also known as v(G), where v refers to the cyclomatic number in graph theory and G indicates that the complexity is a function of the graph. Given a module, whose CFG has e edges and n nodes, its v(G) is : $v(G) = e - n + 2$. Considering a set of several paths gives a matrix in which columns corresponds to edges and rows correspond to paths. From linear algebra, it is know that each matrix has a unique rank (number of linearly independent rows)

that is less than or equal to the number of columns. This means that no matter how many number of possible paths are added to the matrix, the rank can never exceed the number of edges in the graph. In fact the maximum value of a rank is exactly v(G). A minimal set of vectors (paths) with maximum rank is known as a basis. A basis can also be described as a linearly independent set of vectors that generate all vectors in the space by linear combination. So a basis is the minimum number of paths that should be tested. Therefore v(G) is the number of paths in any independent set of paths that generate all possible paths by linear combination. Structured testing as presented in this sub-section applies to individual software modules. It is simply stated: "Test a basis set of paths through the CFG of each module". This means that any additional path can be expressed as a linear combination of paths that have been tested. This criterion establishes a complexity number, v(G), of test paths that have two critical properties : (i) a test set of v(G) paths can be realized ; (ii) testing beyond v(G) independent paths is redundantly exercising linear combinations of basis paths. Therefore the minimum number of tests required to satisfy the structured testing is exactly v(G). Note that structured testing criterion measures the quality of testing, providing a way to determine whether testing is complete. Structured testing is more theoretically rigorous and more effective at detecting errors in practice than other common test coverage criteria such as statement coverage and branch coverage[8]. It is not a procedure to identify and generate test data inputs. The independent test paths can be identified by the Poole's algorithm described below.

## IV. The Poole's Algorithm : A Method to Determine a Basis Set of Paths

A major problem in unit testing of programs is to determine which test data are to be applied. One technique that is in widespread use is to take the CFG from each of the program functions and calculate a basis set of test paths. Path construction is defined as adding or subtracting the number of times each edge is traversed. While this is not a total solution for test data generation, it does provide a good starting set of test data. Poole[5] gives an algorithm for taking a function's CFG and determining a basis set of paths. Two nodes can be either unconnected, connected by an edge in either direction or connected by an edge in each direction. When tracing a path from the source to the sink, a back edge is a edge that leads back to a node that has already been visited. For example, in the figure 1, it is the edge that outgoes of the Y node and incomes in the B node. A CFG contains one source node and one sink. For example, consider a graph with 4 edges: a, b, c and d. The path ac can be represented by the vector [1 0 1 0]. Paths are combined by adding or subtracting the paths'vector representations. Each path in the basis set can not be formed as a combination of other paths in the basis set. Also, any path through the CFG can be formed as a combination of paths in the basis set. Figure 3 shows a simplified CFG. While a complete CFG would not have two edges going to the same destination, this requirement has been relaxed to keep the number of paths to a manageable size for this example. A basis set for this graph is {ac, ad, bc}. The path bd can be constructed by the combination bc+ad-ac as shown in figure 3. The set {ac,bd} is not a basis set, because there is no way to construct the path ad. The set {ac,ad,bd} is also a basis set. Basis sets are not unique; thus a flow graph can have more than one basis set.




| Edge | bd | bc | bc+ad-ac |
|---|---|---|---|
| a | 0 | 0 | 0 |
| b | 1 | 1 | 1 |
| c | 0 | 1 | 0 |
| d | 1 | 0 | 1 |

```
FindBasis (node)
if this node is a sink then print out this path as a
solution
else if this node has not been visited before
        mark the node as visited
        label a default edge
        FindBasis (destination of default edge)
        for all other outgoing edges, FindBasis
        (destination of edge)
else FindBasis (destination of default edge).
```

Fig 3 Simplified CFG and Demonstration of Path Construction and Poole's Algorithm

The algorithm for this basis set method is a modified depth-first search algorithm. The search starts at the source node and recursively descends down all possible outgoing paths. If the node visited has never been visited before, a default outgoing edge is picked, then the current path is split into new paths that traverse each outgoing edge, going down the default edge first. The default edge is any edge which is not a back edge or which later causes a node to have two incoming edges. For example, in the test condition of a pre-test loop, the default edge would be the edge which exits from the loop. If the edge that traversed the body of the

loop was chosen, then a back edge from the last node in the body to the test condition node would have to be traversed later. If the node visited is a sink (no exit edges), then a path in the basis set has been found. Otherwise, the path traverses the default edge. A pseudo-code outline of this method is shown in right side of the figure 3. If we apply this algorithm to a VHDL description, our result will be a set of independent paths. In fact we obtain a number of paths equal to the cyclomatic complexity (see section 2 and 3) with the correspondent edges that are traversed for each path.

## V. First Results and Future Work

Using the concepts issued from software engineering and presented in section 3 and 4, it is obvious that theses concepts are easily used on the control flow representation of VHDL descriptions presented in section 2. We propose in figure 4 a framework for deriving test benches for VHDL descriptions. The proposed approach is based on McCabe cyclomatic complexity, the structured testing method and the definition of the specification of a test benches generator using the Poole's algorithm. We are in the phase of defining the specification of a software allowing to automatically generate test data for VHDL descriptions from the previous concepts. For the moment we have generated by hand input data from paths of a simple VHDL description CFG in order to execute each path. Furthermore we have generated their corresponding output data. The result has been expressed through the compilation of a test bench. Its simulation allowed us to validate a simple VHDL behavioral description[9].

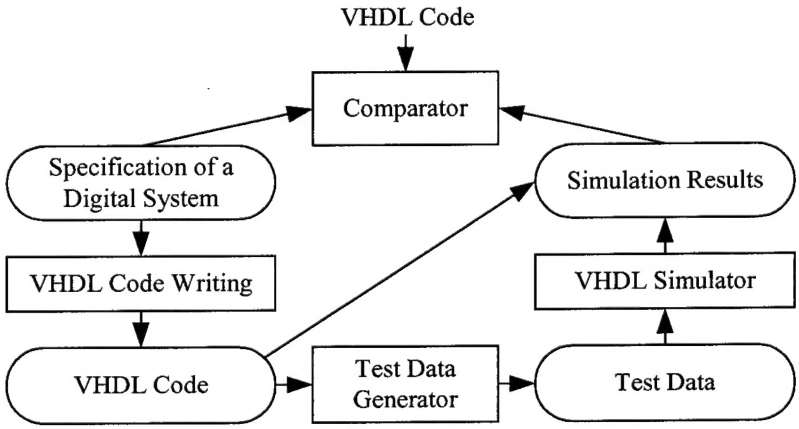



Fig 4 VHDL behavioral description validation scheme

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# UNE APPROCHE A LA PROBLEMATIQUE DES RAPPORTS INTERNATIONAUX EN MEDITERRANEE A TRAVERS LE LANGAGE

Michele BRONDINO

Depuis toujours la Méditerranée se présente sous deux visages antagonistes: le visage unitaire, celui de berceau de la civilisation et le visage conflictuel en tant que foyer de tensions séculaires, plus que jamais vivantes. Ce sont deux visages tour à tour exaltés selon les nécessités ou les approches épistémologiques. Au delà de F.Braudel qui a consacré sa vie à montrer la diversité dans l'unité, reste le problème de l'analyse et de la conception des rapports internationaux dans ce bassin où se croisent effectivement de multiples relations: d'espaces, de sociétés, de religions, de systèmes politiques, économiques, culturels.

Toute approche mène inévitablement à l'exigence d'une définition au niveau du langage qui s'impose comme "key-problem". En effet des termes comme famille, communauté, patrie, nation, état, démocratie, etc, n'ont pas la même acception sur les deux rives de la Méditerranée (rive nord: culture occidentale, rive sud: culture arabo-islamique), car ils sont les phares de deux systèmes différents.
La tentation est alors très forte de faire une lecture des problèmes socio-politiques nationaux et internationaux à travers une analyse des langages. En effet la langue est, de par sa nature même d'agrégation d'une volonté nationale populaire, le lieu où il est possible de lire tous les succès et les échecs des processus de formation des peuples–nations. Selon la thèse de Gramsci, tout passe à travers le problème central de la langue puisque celle-ci est "conception du monde" et donc acte philosophique de conscience critique et de cohérence morale de la personalité "moléculaire" comme de celle "collective".

La lecture linguistique a le mérite d'être particulièrement pertinente et stimulante en ce qui concerne les Etats-nations du Tiers-Monde pour lesquels le problème de l'identité culturelle et de la reconnaissance de l'Autre acquiert une importance primordiale dans le cadre mondial des hégémonies dominantes et dans un monde devenu village global.

Les facteurs linguistiques et épistémologiques s'étendent d'ailleurs bien au-delà des étroites limites nationales, ils s'insèrent dans une dialectique avec les autres réalités, d'autant plus aujourd'hui, à l'heure de l'informatique et des mass medias: "le fait linguistique, comme tout autre fait historique ne peut avoir de limites nationales strictement définies puisque l'histoire est toujours histoire mondiale et que les histoires particulières ne vivent que dans le cadre de l'histoire mondiale."(A. Gramsci)

L'approche linguistique peut être un instrument d'analyse des comportéments et des échanges sociaux, politiques et culturels entre les deux rives de la Méditerranée, divisées par des siècles d'incommunicabilité, puis de dialogue à sens unique, imposé par le colonialisme, et aujourd'hui par les différentes prises de conscience de l'après-indépendance: de la décolonisation au néo-colonialisme financier et médiatique.
Constat de difficultés à tous les niveaux: à la base il y a un manque de moyens de communication et un manque de connaissance des rapports internationaux. Ainsi se pose le problème de se connaître réciproquement pour entamer un dialogue paritaire: de l'économie à la politique, du social au culturel.
Le cas paradigmatique de l'Algérie d'aujourd'hui en est la démonstration où "meurt ce qui est vieux et n'arrive pas à naître ce qui est nouveau" à l'aube du XXIème siècle.

# The Coexistence of Culture and Technology

Nuutti Pursiainen
Presentation in ATW´99,
June 10 1999

In my discourse I will deal with the relationship between culture and economy on a rather general level. It is my idea to emphasize the importance of regional cultural prosperity to the inhabitants of the region concerned. I venture to insist that a culturally distinctive area - if given a possibility to manifest itself - will offer good preconditions also to those active in economy/ economic life. This concerns as well those working with high technology, whose role as promoters of economy is getting increasingly important all the time.
Even the most cynical observer will have to accept the fact that social peace, i.e. a state of peace inside a community is better realized when things are looked at from different points of view and there is a tendency to reach a compromise in conflict situations. Allowing the appearance of regional cultures does not indicate weakness in central administration but rather an acceptance of realities. In this way different areas are allowed to to display their own strenghts and , in the best case, these strengths can be made use of economically, too. At its simplest a utilitarian point of view is shown in the fact that a possibility to produce regional cultural practices as such will stabilize the situation in a community. Simplifying a bit, we could state that fighting for one´s own rights will change into a peaceful conservation of traditions and, on the other hand, an activity creating something totally new. An inner stability of regional communities will also benefit those who practise economy, high tech business enterprises as well as sectors of more traditional economy.

In order to support these views, I will produce justifiable interpretations as to the events in recent history in Corsica. My choice of example subject does not imply that Corsica would in some negative way be a unique case in the observation of the relationship between regional pursuits and economy. Parallel observations could be made in connection with an examination of other European regions as well. Choosing Corsica as my example case is simply due to my own personal interests.

In spite of considering historical examples and courses of events it is not my purpose to explain in a state of naive faith what measures should have been taken in earlier situations. I rather tend to present factors affecting those situations. According to my view, this way of approaching will present an opportunity to minimize risk factors of the same kind in connection with economic development projects. Thus something can be learned from mistakes in the ways of action that led to earlier problem situations.

*A short excursion to examples in recent history*

Plan d´Action Régionale was enforced in 1957, an act the purpose of which was to start action in order to support financially unprosperous areas and raise their standard of income. Corsica´s share was two development programmes:
SOMIVAC (Societé de la Mise en Valeur de la Corse) and SETCO ( Societé pour l´Équipment Touristique de la Corse) The purpose of the former was to develop the agriculture of the island and the aim of the latter was to help in making tourism a new industry on the island.
The planners of centrally-led programmes saw the area of Corsica as a great economic possibility provided that workers could be brought in from outside the island. According to the original plans they aimed at large-scale crop husbandry in cultivable areas of the eastern coast. In addition, the idea was to invest in high-quality species of grape. The governments of the Fifth Republic, however, cut down investments planned for the development of Corsica. The strategy of action observed was one of aiming at as high profits as possible at minimum costs. As a result of a cultivation policy contradictory to the original plan the wine production increased tenfold from 1959 to 1969. Corsican agriculture was, in fact, forced to become export-orientated, and farmers were led to grow citrus fruits in addition to viticulture. The centrally-led agricultural policy to improve the economic state of Corsica was irresponsible. Along with investments in the coastal regions yielding quick profits the interior parts were completely forgotten. Large-scale cultivation and quickly built mass tourist attractions made the living conditions of people engaged in traditional industries tighter. In most cases, moving from one pasture to another along with the changing of the seasons was concretely hindered by the new building complexes in the coastal regions and by fenced fields. Items included in the original Corsican agricultural development programmes like reducing costs of transport, agricultural education and developing small industries were, practically taken, passed over.

Similar irresponsibility can - at least afterwards - be seen in the tourist development plans of the island in the mid-sixties. Planners of the centrally-led programme believed tourism with its multiplier impacts to be the most promising economic factor in Corsica. They hoped the area would be a new Riviera. According to the calculations of the planners, more than two million tourists a year were expected to arrive in Corsica mainly during the summer season. In the plans this was imagined to happen without any effect on the inhabitants or the nature of the island.

Along with the "tout vignoble" -policy the agriculture of the island was made export-orientated. The "tout tourisme"-policy for its part had a strong effect on the development of the economic and social structural changes of the island. Along with the economic development plans carried out by France Corsica was made part of a larger consumer society in spite of the fact that that the island´s own production structure became so unstable and vulnerable. Concentrating agricultural activity on two export products, wines and citrus fruits, made for its part tending cattle collapse as an industry. Because of this policy Corsica became dependent on continental France as for foodstuffs. Actions through which quick profits were pursued within a short span of time had, in the long term, an unpredicted impact. A regional stir was partly developed by these social evils.

In connection with the example cases I mentioned above we naturally have to take notice of the spirit of the times. The idea of a national state at the time emphasized national unity and people not divided into distinctive separate collective bodies. It is this basic idea of

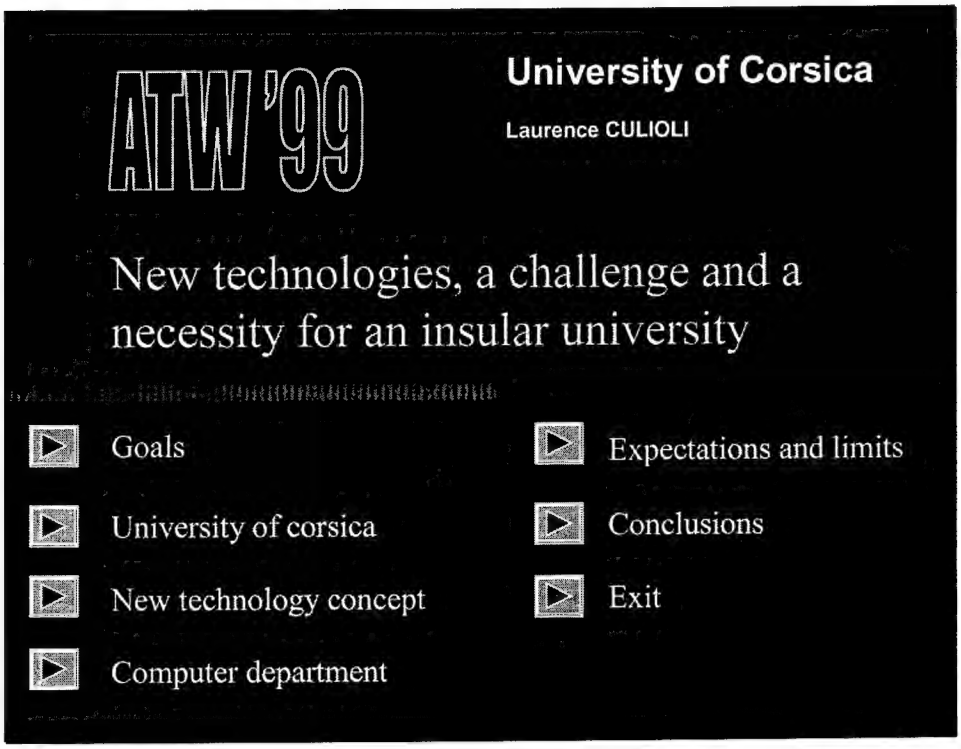
a collective policy that already brought about conflicts as regional aspirations were suppressed in different parts of France. Besides t he idea of a national state together with a policy based on principle, problems were also caused by another political strategy that can more easily be judged as a mistake. There was an effort to integrate Corsica as part of French economic culture by taking unskilful measures.The economy of the island and the herdsman´s traditional source of livelihood experienced a collapse.Similar examples are to be found in several parts of continental France. The fate of Corsican herdsmen is an example of the worst kind of a situation in which a new economic policy with its innovations does not meet the local culture at any level.

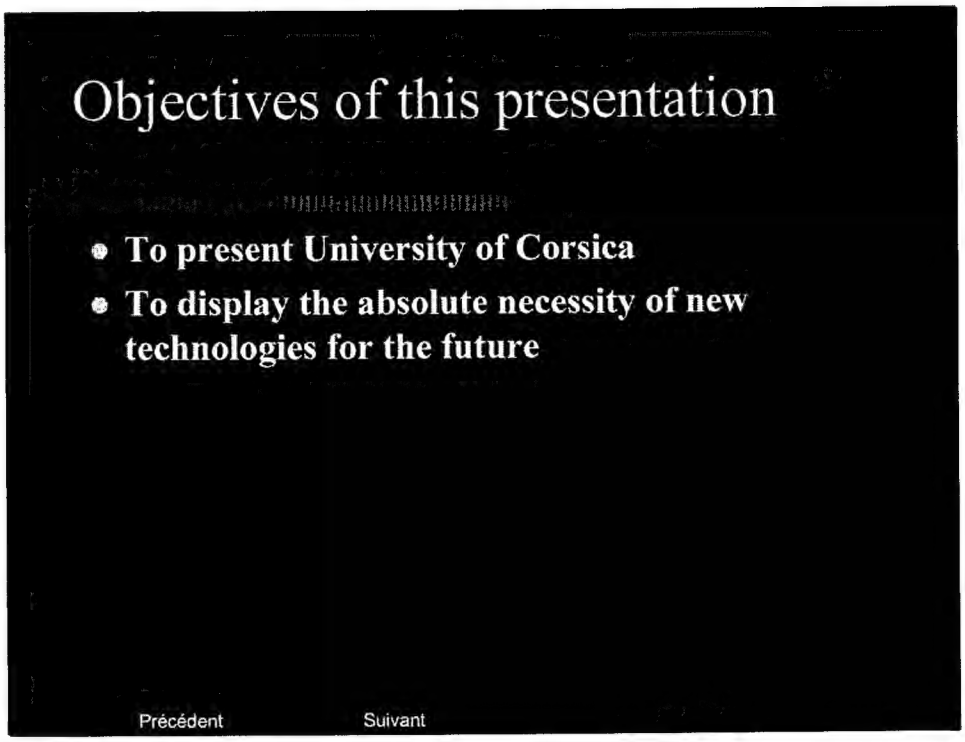
Nowadays the attitude towards regional aspirations and the cultural uniqueness of different areas has changed in France, too. The policy of national unity has been left behind little by little, and the ability to tolerate regional diversity has improved. Perhaps it is possible even to talk about appreciating regional traditions in some cases. In Corsica this trend has been seen in a self-government of some degree. There is no reason to overlook the fact that in the state of the Corsican language there has been a change into a positive direction. (In this connection I shall not deal with these interesting phenomena more closely.)

Along with this positive development as for regional aspirations and regionalism, regional communities will have more possibilities than before to shape themselves and their economic as well as cultural activities. In the case of Corsica this is seen as a cooperation directed towards Italy in sectors of both culture and economy. The prevailing positive tendency in question, in my opinion, shows rather clearly that economic welfare and the development of economy as well as maintaining them - it makes no difference whether more traditional sectors of economy, or high technology, or its newer applications are concerned - require tolerating and accepting regional cultures.

# Communication, data processing system and new technologies : challenge and necessity for an insular university

*Laurence CULIOLI*



# 1. University of corsica

- 1.1 Location
- 1.2 A bit of historical
- 1.3 Curricula
- 1.4 Partners

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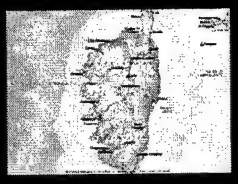
# 1.1 Location of corsica



Located in the mediterannean sea, the economy is based on tourism, agriculture, breeding and administrative employment.

| Corsica : | United-states : |
|---|---|
| 185 km long and 85 km wide | 9 363 124 km² |
| 250 362 inhabitants | 252 494 000 inhabitants |

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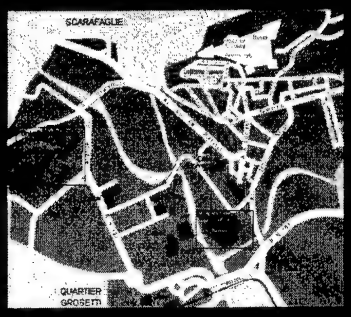
# 1.2 A bit of history




- Born in 1981
- in the middle of Island, in Corte
- Third economic center between Ajaccio and Bastia
- Nowadays : 3500 students, 300 teachers and 100 administrative employees
- Upon 3 differents sites within the city
- A wide range of curricula :
  from initial, technological to professional
  from bachelor degrees and master (2,3,4,5 years) to doctorate (8 years)

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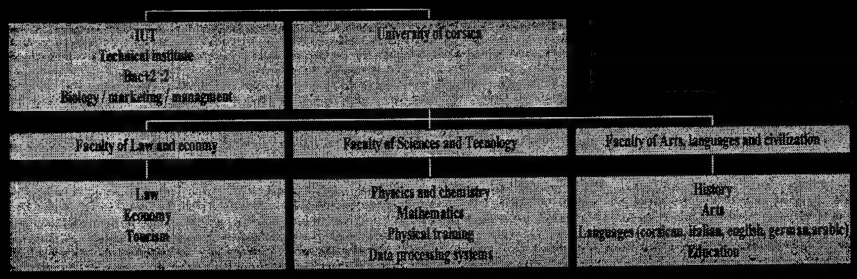
# 1.3 Curricula

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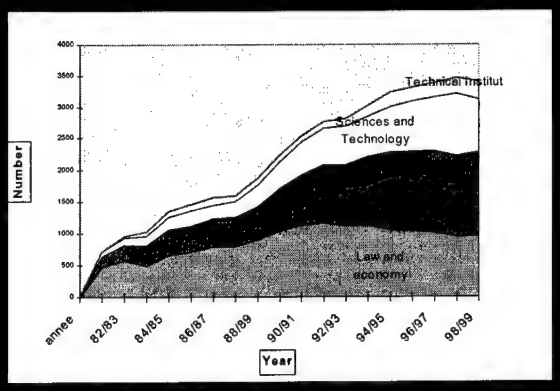
# Evolution of student 's number per main departments




- The total number increases each year
- Increasing rate sciences and arts
- Decreasing rate for economy and law
- Equilibrium between pedogogical offer, student 's expectations, and job opportunities

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# 1.4 Partners

- French and Foreign Universities
- Compagnies and industrial fabrics in Corsica and mainland
- Ministry of education
- Suppliers of materiel, of know-how, of counsel
- Cities, countries, Region and administrative structures
- Transfer of information, technology, knowledge is a necessity to communicate from one partner to another.

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# 2. New Technology concepts

- 2.1 Opening the world
- 2.2 New technologies at the UCPP
- 2.3 Data processing system

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## 2.1 Opening the world

- To fight the insularity of Corsica and the situation of Corte, mountain City of 5000 inhabitants in the core of the island
- To promote the exchanges of ideas, knowledge and culture : fondamentals of the University
- To answer to the basic needs of teachers
- and basic needs of students (courses, books, informations…)
- To develop a cultural life
- To organize communication with every partners
- To promote the image of the university
- To help development and expansion

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## 2.2 New Technology

- Problems and goals : necessity of communication, but also necessity to think about New Technology 's dynamic tribute to heavy administration university.
- Question : What are new technologies ?
- Answers :
  - All ways allowing information transmission, writing, speaking and visual data,
  - Creative and development tools.
- Choice : computer sciences and multimedia.

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## 2.3 Data processing system

- Four orientations stand out the horizon of the new century :
  - Database processing system and appropriate softwares
  - Powerful Scientific calculations system
  - Office automation
  - Pedagogical networks, computers and softwares

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# 3. Computer department

- 3.1 Technical tasks
- 3.2 Three concrete result
- 3.3 Network
- 3.4 Management
- 3.5 Internet and www



# 3.1 Evolution

- 1990 - the beginning of the adventure :
  - the first computer was set up to take care of accountancy , software in cobol language : two users.
- 1993 - the computer department is created :
  - 20 computers and a local network are installed between two buildings of the university,
  - a temporary connection with the mainland is opened
  - a software is developped for the registration 's office,
  - a policy of purchase with suppliers and users is builded.
- 1998 - we enter in the New Technologies area :
  - 7 employees, 400 computers on local network, 10 servers, 6 training rooms,
  - a strategy and a political plan of development is proposed .

# 3.2 three concrete results

- **Network : RETECOR, a mainland-connected regional network linking 15 companies throughout corsica**
- **Management : AMUE, an institute of modernization for french universities**
- **Communication : Internet, mail and www**

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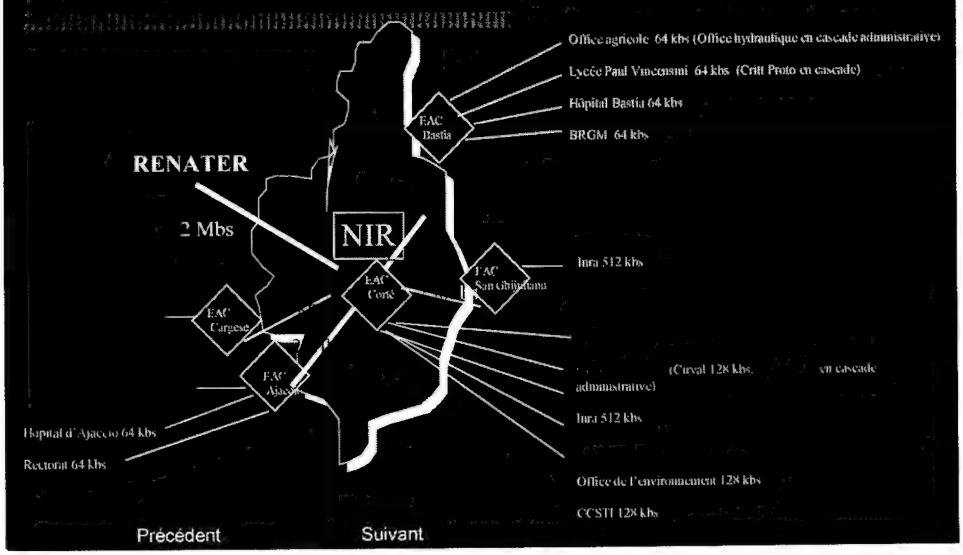
# 3.3 Retecor

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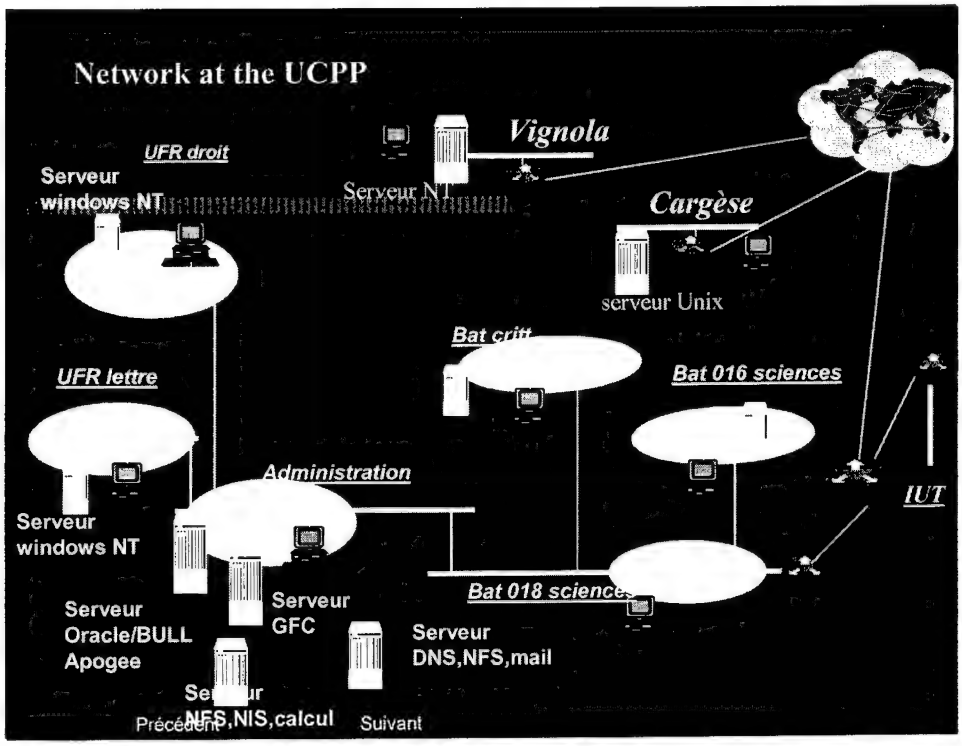


# 3.4 AMUE for the management

- 1997 : The AMUE, Establishment and University 's Modernization Agency, intends to give universities modern, powerful, user-friendly and homogeneous tools. This agency results from common will of universities, computer departments and ministry of education.
- Co-financed by government and universities, AMUE develops softwares for accountancy, registration's office, pay, staff management based upon ORACLE products.
- AMUE helps universities, as technical and functional support, before, during, and after softwares' installation.

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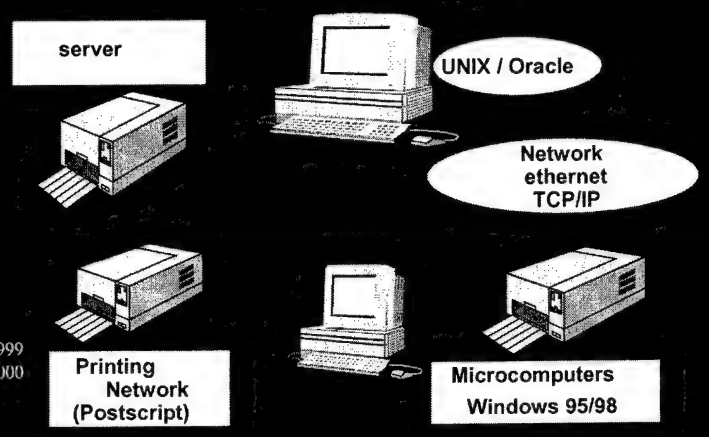
# APOGEE : Software for students and education management




20 users in 1999
50 users in 2000

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# APOGEE fullfills university 's expectations

**Manager**

- to have reliable informations,
- to improve means of action,
- to help in short and long-term forecast,
- decision help .

**Student**

- to reduce printing time for results and diploma,
- to simplify registration,
- to improve information : general information, curricula orientations,
- to simplify timetable readings .

**Teacher**

- to know the number of students, the options they choose...
- for computations of marks and results,
- for jury 's deliberation,
- to have statistics on exam results

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# 3.5 Communication

- every staff employee and teacher has his own email address.
- On of our 2000 's goal is to give each student a email as soon as he/she registers.
- www



# 4. expectations and limits

- 4.1 Initial conditions
- 4.2 Using and users
- 4.3 Exponential technical revolution

# 4.1 Initial conditions

- Definition of needs in a clear language
- Analysis of these needs, goals and priorities
- Users' training
- Human and financial ressources

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# 4.2 Using and users

- Training is mandatory :
  - The learning has to begin as soon as possible, eather at school or at the university,
  - Over the years, users 's level increases and training 's level has to increase accordingly.
- Suitability : friendly and working tool for users. (and not only for computer engineers)
- Communication : Users have to know their needs, and to explain them with simplicity

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# 4.3 Exponential technical revolution

- Training : technical revolution leads to continous training for computer engineers
- Wide range of abilities : Analysis, programming , teaching skills, technical knowledge
- Network effect : since 1984, the CSIESR, computer departments of french universities proposes technical training , email adresses, forum exchange (experiences and information).



# Conclusions

- to be abble to apply New Technologies is a strategic aim for our young university
- very quickly, we need to provide good services within our university and we need to fight against our geographical position using this New Technologies.

# Arbitrage, monetary policy and economic evaluation : a case study

**Christine BARTOLI**
**Doctorante**
bartoli@vignola.univ-corse.fr

**Nadine LEVRATTO**
**Chargée de Recherche CNRS**
levratto@vignola.univ-corse.fr

SDEM-URA 2053 CNRS-Université de Corse
Centre Scientifique de Vignola
Route des Sanguinaires
F-20000 AJACCIO
☎ +33(0)4 95 52 41 41 +33(0)4 95 52 41 42

The increase of the public expenses on one hand and the growing intervention of the public authority, on the other, raise a lot of questions about the efficiency of public policies. The different laws of decentralization implemented since 1982 have contributed to extend the role of the local authorities which can now act at many levels of the economic system. These new competencies and the corresponding financial weight they have reached originates debates about the appropriateness of the use of the public funds. From this point of view, the regions have more and more prerogative as far as economic development is concerned (Falzon, 1996). Consequently, they are able to propose either subsidies that aims at promoting investment or employment or indirect actions that results in facilitating the firms' indebtedness. The list of the existing subsidies dedicated to local economic development has becoming increasingly longer and complex, this is the reason why it is necessary to get a panel of objective indicators that allow to appreciate the efficiency of these measures and, more particularly, the correspondence between their expected and effective results.
These two elements are thus at the origin of any economic evaluation of a public action, what appears to be a major trend in the implementation of public policies, not only in France, where this phenomenon emerged lately, but in all the OECD countries[1].

The concept of evaluation economic is useful not only from an ex ante but also from an ex post point of view. Indeed, the evaluation of a policy efficiency, may be retrospective since, experienced after the measure's implementation, it aims at informing the decision makers about the adequacy between the legal, administrative and financial tools used. Besides, economic evaluation gets an ex ante function and, in this sense has to be used as a " tool of clarification and comparison of various stakes " (Cohen de Lara, Dron, 1998) in the process public decision. Whenever the ex ante role of the evaluation is neglected, one can see raise questions about the " good use " of public funds, even if the responsible authority try to justify its decision having recourse to the use of an ex post evaluation of the measure experienced.

This work aims at providing an example of the economic evaluation of some interest rate rebates that are considerate as a financial measure dedicated to improve the financial positions of firms reducing the cost of their external funds. Trying to appreciate the real effects (on investment and employment) of a monetary instrument, we will proceed in four steps. The first section, will remind the basic principles of monetary interventionism whereas the second

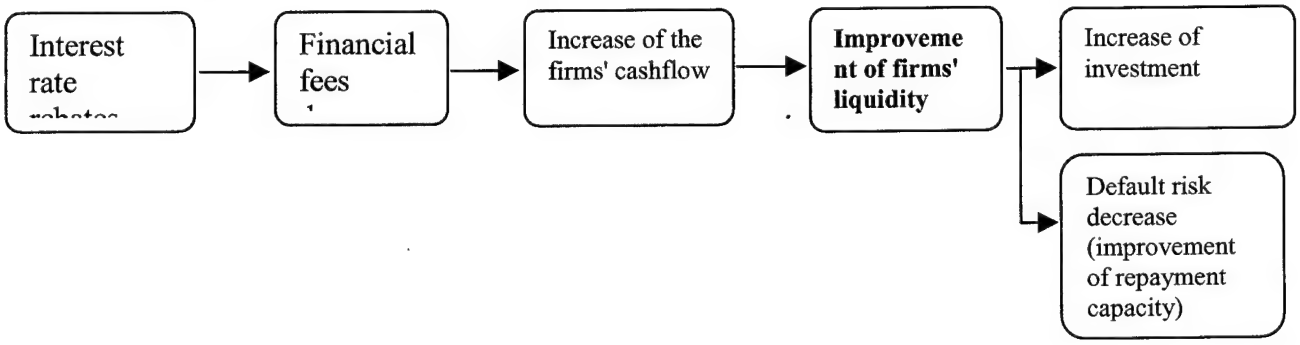
[1] A comparative analysis of the various evaluation methods and details of implementation are available in the B. Larrera de Morel report of (1997) or in the Senate one (1995).

section, will present the fundamental aspects of economic evaluation. Then, after having presented, in a third part, an example of an ex post evaluation, we will devote the last and conclusive section to the presentation of some normative aspects that can be of some help as far as the concrete implementation of monetary policy instruments is concerned.

**The stakes of monetary interventionism**

Rebates on interests rates arises as a standard case of monetary instrument since they aims at influencing real variables, here the economic activity, reducing the price of money and thus the financial fees paid by borrowing firms. One has to keep in mind that, if most of the monetary policy instruments are implement in order to influence either the quantity or the price observed on the money market, interest rate rebates act as a price distortion directly impulse by the public authority, between the non financial agents that may benefit from such a measure and the ordinary ones. Such a measure used to be implemented during the end of the seventies and the beginning of the eighties, what can be easily understand since this period was simultaneously characterized by a credit rationing and a high level of interest rates on credit. It is however much more surprising to observe rebates whereas interest rates have reached a level that is so low that the central bank considers that they will not decrease any longer and that the floor has been reached.

The macroeconomic framework corresponding to this sort of practice is rather conventional, since it rests upon a causal relationship between investment and interest rate, such as one can find it in an IS-LM model. Embedded in a normative and finalized approach that links some independent variables, i.e. monetary instruments, to endogenous ones (the final targets) either directly or going through some intermediate targets (Varoudakis, 1994), this approach originates the following conception of a monetary policy resting upon the credit cost :




To measure the impact of a financial action implemented by a local authority, it is first of all necessary to identify several objective variables that are expected to be either directly or indirectly related to the controlled variable[2]. As far as investment (hereafter quoted I) is concerned, one may consider that the main explicative variable consist in the interest rate level (noted r), i.e. the price of loanable funds, what is in perfect accordance with the IS-LM framework in which one of the structural equation is : $I = f(r)$

[2] Let's recall that, according to Tinbergen principle, a macro-policy must obey to a simple rule according to that the number of targets equals the number of instrument. In this ideal case, public authorities can dichotomize the problem of economic policy implementation; firstly they choose the aims to reach and then they determine the appropriate level of pertinent instruments. If the economic structure changes, the only observed variations affect instruments but the targets remain unchanged.
This basic principle is completely forgotten in the case study presented hereafter since interest rate rebates have to induce i) an increase of investment in growing firms and ii) a decrease of the item "note payable" for the firms that experiment solvability problems.

Whenever public authorities try to influence the interest rate, either on behalf of an open market policy or, if at a regional level, through rebates, it confirms the idea according to such a variable acts as an essential pivot of the economic activity. The rebates takes however a form somewhat more complex to implement than the general reduction of the interest rates by means of interventions on the money market since it also requires the mobilization of budgetary instruments. We are thus facing a selective conception of monetary intervention according to from distortions of relative prices on credit market result a kind of advantages given to some groups of firms in order to incite them to behave in a desired way.

The measure we will study in the third section aims at helping some firms to develop or to react better to financial problems. To do so it causes a bias in the market mechanism of interest rates determination, since some potential borrowers will pay a lower price than what they would have if the competitive system was in force. This so-called correction fits well with the definition of prime rate credits given by the French central Bank according to which " any credit for which the borrower profits from a rate of interest lower than that he would normally have to pay must, *a priori*, be consider as a privileged source of financing".

This kind of policy appears to be a favorite means of intervention used by the French governments since the fifties, but it was especially used during the first half of the eighties since the qualitative and quantitative importance of rebates really reached a peak[3]. At this time, the interest rates rebates were associated to an institutional credit rationing whose they tried to attenuate the depressive effect proposing not only to leading but also to industries facing economic difficulties cheaper credits than what normally proposed by banking institutions. Nowadays, even if less employed, these measure still exist since, in spite of a generalized domination of market mechanisms in the national system of financing, the selectivity is used as a mean to rectify some inequities or to promote the development of activities that contribute to the improvement of the general welfare. This is why exporting industries or activities able to generate cumulative growth effects still benefit from special credit offers partly taken on the national budget.

One can be anything but surprised to observe that, despite the high cost it generates and the spurious effects it generates, such a measure still use to be implemented in some regions. The opportunity of this kind of public intervention, justified by some empirical evidence concerning the existence of a causal relationship between the interest rate and the global output measured by the GDP[4], is reinforced by some microeconomic elements. Indeed, several theoretical and empirical works dealing with SME's finance show that cash flow degradation, non repayment problems and default probability depends strongly on the weight

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[3] From 1982 to 1985 the interest rate rebates grew a lot since, before being suppressed in 1986, they represented about 40% of the total amount of credit supplied to French firms. The high cost and the weak efficiency of this measure supposed to be dedicated to SME's but mostly used by large firms explained why it almost completely disappeared when, in 1986, the French government stuck to the general tendency what supposed a reinforcement of competitive conditions in the financial sector. Cf. Penaut and Gaudichet, 1985 or Debonneuil and Pages, 1987.

[4] Discussing about the pro and the cons arguments in the debate between keynesians and monetarists about the relationships between monetary and real variables would not be here opportune. Let us precise that the theoretecal framework we will implicitly refer to is the New Keynesian Economics, such as presented in Greenwand and Stiglitz, 1988. According to this approach, it is less the price of loanable funds than their availability that originates macroeconomic fluctuations. Transposed at a micro level, it gave rise to the credit rationing theory which rests upon a double relationship, the first one relates credit supply to expected default of the potential borrower whereas the second one stipulates that the demand of credit is mainly determined by the amount of profit desired by the entrepreneurs. Thus, reducing by a non market mechanism the probability of default, interest rate rebates push up the credit supply and then, release the firms' financial constraint.

of the item "Notes payable" and then on the cost and the amount of debts. Although purely financial, interest rate rebates are supposed to be able to generate not only an improvement of the income statement and of earnings, but also a change of the firm's productive[5] and financial[6] behavior.

It is thus, generally admitted that investment at the level of a firm, an industry or a nation is inversely related to the level of interest rates. Nevertheless, the effective sensitivity of the real variables to the monetary variable remains difficult to be predicted since the financial leverage effect can only be observed, i.e. measured ex post. So, since the implementation of a monetary policy measure induces budgetary costs that can be either direct as is the amount of rebates granted or indirect, such are the operating costs of the system, wondering about the effective impact of this kind of action becomes judicious. This is the reason why, the following sections will be devoted to the measurement of the effective impact of a anonymous real case of interest rate rebate. However, before undertaking the genuine economic evaluation, the underlying principles of the method have to be reminded.

Economic evaluation principles

The State intervention in a market economy is considered as a « corrective distortion »; indeed in a complete system of markets and in the absence of external effects, market mechanisms grants a Pareto optimal resources allocation. If some irregularities in the competitive system are taken into account (for example if the banking system does not fulfil its function correctly), Public authorities may create a second distortion which will allow to reach an collective welfare higher than what would have been observed if no intervention were planned. Here lies the main teaching of the so-called welfare economics (Pigou, 1920).
The need of evaluation lies in the justification of the State interventionism. This is what Bernard Perret, general reporter of the French *Scientific Council of Evaluation* from 1990 to 1998[7], means when he says that one of the stake of evaluation consists in legitimate the debate about the public authority way of functioning[8].

Indeed, despite the traditional delay that exists between the continental Europe and the "English speaking" countries, economic evaluation became an up to date concept, useful whenever impact or feasibility studies have to be undertaken or if a studies devoted to the measurement of public policies effects have to be realized. Granting a satisfactory use of public funds is now a common exercise, sometimes organized by the laws[9] to systematize the follow-up of the actions of public policies. If the concept of evaluation seduces so much it is because its operative aspect. It developed at the crossroads of the scientific knowledge and political action. It also permits to test the robustness of economic theory and to bring a

---

[5] It is appreciated using indicators such as investment and employment.

[6] Financial performances are generally characterized by the weight and the cost of debt, but a lot of other ratios defining the financial autonomy, the interest and other finance charges, the borrowing capacity…, can be used.

[7] Independent organization created by the decree of January 22nd 1990 and relating to the evaluation of the public policies. Its mission consists in « supporting the development of the evaluation methods and in defining a deontology on the matter " (article 8 of the decree). It was replaced by the National Council of Evaluation (decree of November 18th, 1998) whose secretaryship is ensured by the Commission of the Plan. Bernard Perret is a member.

[8] in *The Letter of Reflex*, n° 9. Reflex is a network of teams engaged since many years in research, study and action on the urban phenomenon.

[9] For example, the Law of December 20th, 1993 relating to Work, Employment and the Vocational Training (Law n° 93-1313) contains in its IVth part *Co-ordination, simplification and evaluation*, the evaluation and possible revisions of the initial text schedule.

judgement about the public policies consistence referring to empirical data what helps to clarify the decision-making process, in its elaboration or in its revision.
Evaluation practices are twofold: on the one hand, one finds quantitative methods which try to measure or anticipate the results of an action and, on the other hand, have been developed methods which are nearest from sociology but whose reputation is less important because of the lack of operative purpose. In this paper, we will only pay attention to the quantitative aspect of the evaluation and the example we will present consists in a monetary policy evaluation that rests upon quantitative techniques.

Expressing a community wishes and values, a public decision may thus be considered as a way to reveal collective preferences. However, as mentioned earlier, public intervention has direct and indirect costs : any new measure has to be financed not only for itself but also for the additional functioning expenses its implementation will generate added to the possible failures (eviction effects are the most frequent) of the public intervention in a decentralized economy[10]. These costs can only be evaluated *ex post*, i.e. after the public intervention.

*Ex post* evaluation allows to make comparisons between the expected results of the implemented measure and its observed results or, in other terms, to compare economic theory or political doctrines with measured or built indicators. A precise set of conditions must be established in order to rationalize the data collecting. Modelling and the related quantitative techniques open up interesting work prospects mainly because they rationalize the comparison between expected and observed results. The example we develop further shows the interest of a statistical analysis and thus demonstrates why, whenever possible, and it is indeed the case for monetary policy, a quantitative evaluation method has to be proposed.
The use of evaluation as a decision tool is everything but frequent. The point is that, instead of being observed, results have to be anticipated so that the described situation becomes less complex in the sense that the choice is restricted to a political problem of arbitrage between several valuated aims.

Put in a more general way, any economic evaluation must aim at reaching several objectives such as:
- the valuation of the systemic administrative efficiency what is equivalent to the measurement of the global performances of the system;
- the valuation of the direct effect the studied measure provoked on the targeted population, i.e. the microeconomic effect of the measure.
- the valuation of the global effect, i.e. the macroeconomic consequences of the implemented policy. At this stage, it is important to ensure that all the indirect effects have been taken into consideration. Since an action can improve the situation of some agents to the detriment of others, the observers will preserve themselves against omission considering not only the industries or the groups targeted by the measure but the whole economic system.

The quality of the realized studies and the sort of evaluation method to use in order to adjust the public policies implemented according to their observed effects are thus two essential topics in the rethinking of public action.

Most of public policies evaluation studies are rest upon cross-section data sets, extracted from ad-hoc surveys or from administrative data files. Even if one pays a great attention to data improvement enlarging the covered period, before and after the measure implementation, cross-section studies can only give partial and incomplete and sometimes disappointing

[10] on real costs of the official intervention compared to market failures, see Mueller, 1984.

results. The use of *ad hoc* data extracted from samples far from being sufficient. The ideal method would consist in giving to the evaluation group the means of producing its own data, what could be done if an administrative follow-up were planned. Time-series are really necessary to the evaluation of long-term effects of a public policy and

- trends identification,
- industrial demography,
- differentiation between temporary and durable effects

are topics policy-makers are interested in when they have to decide the way public funds will be allocated.

Appealing to specific surveys can be useful if the aim consists in having a picture of a specific situation. However, having recourse to such a method can be risky because a large part of the targeted population will not fill the questionnaire and the default risk is larger than the deception the implemented measure inspired to the people were important. Knowing why economic agents are not satisfied with what they benefited from is nevertheless interesting and brings complementary information to the good reporting done by some inquired persons. All the public actions cannot however be submitted to an evaluation study; but this is the first mean of preventing the risk of lack of co-operation inherent to the studied measure.

Ideally, what would have to be done prior to any study is a collect of time-series. It is however possible, providing that data are consistent, to evaluate expected effects of any policy or to adjust it according to the observed gap between the aims and the real effects. Data producing by groups of regularly renewed actors would allow to understand better not only the microeconomic mechanisms of a given public measure but also the underlying global mechanisms that originate its macroeconomic effects.

The arbitrage between antagonistic public policy goals can thus lie on the concept of economic evaluation. It is always possible to justify *ex post* public policies choices or to adjust a policy according to its efficiency. Using economic evaluation lies thus on the acquisition of knowledge about the economic system what includes the modeling the economic system, its real functioning and its dynamic properties. We will get thus a description of control mechanisms (search for the viability conditions) whose simulation allows to improve the economic performance (search for efficiency).

The evaluation of economic policy effects lies on a sample of tools as:

- a system of date collection and storage,
- models built by analysts in narrow co-operation with the authorities in charge of the economic policy implementation,
- tools of decision-making help,
- quantitative instruments of prediction,
- criteria of validity for observed results.

Gathering these components as a whole is the necessary condition to formalize the economic policy implementation lying on an instrumental approach and allowing to answer the question of the public policies evaluation.

**A case study**

The study we present in this section is a real case. It deals with the economic evaluation of a measure of interest rate rebate, which is dedicated to two kind of firms, quoted « group A » and « group B ». It indicates the quality of the group, A>B.

The method we used is a quantitative technique based on an econometric modelling. Data we used are cross-section ones and they were collected by a survey. The questionnaire built for that work allowed us to collect data concerning each beneficiary, before and after the aid granting just as well as general data on the company structure and on its leader. We had approximately 150 companies. The questionnaire was also submitted to a group of companies which didn't benefit from the measure and called « reference group », it contained about 100 companies. The resulting estimations we present rest on a total of 176 asked companies.

Methodology used consists in modeling a set Y of variables (endogenous or explained one) that depends on a set X of variables (exogenous or explanatory ones), knowing the two sets are composed of observed variables, i.e. collected during the survey.

Method:

We used a qualitative variables econometrics method, so that the set Y is composed of probabilities: we attempted to estimate the probability of benefiting from the measure according to variables we will call « companies characteristics ». We also modeled the probability of having favorable economic scores (turnover increase, net creation of jobs...) for a company, depending on it benefited from the subsidy or not.

The aim is thus estimating probabilities which are conditional to the set X in order to know if supported firms populations are structurally different from unsupported ones. In fact, this aim is twofold: we wanted to describe the characteristics of the supported firms and, besides to measure the effects of this subsidy in the companies and, more generally, the indirect consequences on the economic system. In this section, the diagram of an *ex post* economic evaluation appears, i.e. an evaluation used to justify a political decision, as far as the continuation, the widening or the abolition of a measure is concerned.

Let's quickly present the methodology. Whatever estimated probabilities (Y) and the types of economic actors concerned (producers, consumers, firms of A quality or firms of B quality as we have in this work, A>B) and thus their individual characteristics (X), the use of the method and its operational aspect remain the same.

We specified « logit » models which can be justified referring to stochastic utilities analysis. Whenever collective utility when a firm is supported is higher than when it is not, the demand for subsidy expressed by a company will be satisfied. The aid granting corresponds thus to an expected utility maximization problem. We can indifferently consider that the randomness of the utility comes from the basically stochastic nature of the individual choice since the agent choose two different options in two identical situations, or from a lack of information. The result is that this myopia gives a random nature to the final decision.

« Getting the subsidy » is a dichotomic variable of Y, coded into 1 (agreement) and 0 (refusal). Let $U_{i1}$ and $U_{i0}$ be the utility, respectively, got by the system from the agreement and from the refusal of the aid to a firm i. Let $x_i$ be the characteristics of this company i. We have then:

$$U_{i1} = x_i'\beta_1 + \varepsilon_{i1}$$
$$U_{i0} = x_i'\beta_0 + \varepsilon_{i0}$$

The probability of the event « the subsidy is granted to the firm » is thus defined as :

$$
\begin{aligned}
P(y_i = 1) &= P(U_{i1} > U_{i0}) \\
&\quad P(x_i'\beta_1 + \varepsilon_{i1} > x_i'\beta_0 + \varepsilon_{i0}) \\
&\quad P(x_i'[\beta_1 - \beta_0] > \varepsilon_{i0} - \varepsilon_{i1}) \\
&\quad P(x_i'\beta > \varepsilon_i) \qquad \text{with } \beta = \beta_1 - \beta_0 \\
&\qquad\qquad\qquad\qquad\quad \text{and } \varepsilon_i = \varepsilon_{i0} - \varepsilon_{i1}
\end{aligned}
$$

Then $P(y_i = 1) = F_\varepsilon(x_i'\beta)$

If $\varepsilon_{i0}$ et $\varepsilon_{i1}$ are characterized by a bi-exponential law, also called extreme values law, $\varepsilon_i$ follow a logistic law (law $F_\varepsilon$ in the previous formula) and the specified model is a logit one. The probability of the event "benefiting from the subsidy" can then be expressed by the following function:

$$P(y_i = 1) = \frac{\exp(x_0\beta_0 + x_1\beta_1 + .... + x_m\beta_m)}{1 + \exp(x_0\beta_0 + x_1\beta_1 + ... + x_m\beta_m)}$$

The estimation work aims at identifying the $\beta$ vector of the parameters. Each parameter ($\beta_0 \ldots \beta_m$) is linked to an explanatory variable, i.e. a variable ($x_0 \ldots x_m$) picked among the set X supposed to influence the probability of « benefiting from the measure » or the probability of « having good economic indicators », provided the firm profited from the subsidy or not.

Such a model is non-linear and this non-linearity complexifies the interpretation of the estimated coefficients. In a linear model, the parameter gives the marginal effect of the variable it is linked to, on the endogenous variable. With a non-linear model, two elements can nevertheless be interpreted:
- the sign of the coefficient: when the sign is positive (negative), the variable increases (decreases) the probability of the event « getting the subsidy », other things being equal.
- the odd-ratio (the odd-ratio exponentially depends on the parameter if the exogenous variable considered is dichotomic and coded into 0/1, which is the case for the almost all the variables directly observed in the survey or elaborate from the questionnaires) more precisely quantifies the variation of the probability of « getting the subsidy ».
In fact the parameters are interpreted in relation to a reference element built to avoid colinearity problems between the explanatory variables[11]. The parameter gives the influence of a characteristic in relation to the characteristic of the reference element. It is the same one throughout the whole work, whatever the model being considered. It is a company whose turnover is stable and whose leader has the A-level i.e. the highest diploma.

[11] When the variables are coded into 0/1, some variables are such as their sum is always equal to the constant variable. We must remove one of the variables which becomes a characteristic of the reference element. For example « having the A-level », « having a lower diploma than the A-level » and « having a higher diploma than the A-level » are three variables whose sum is always equal to 1 for each element of the sample. We remove one of the three, the first one for example, the reference element has thus the characteristic « has the A-level ».

Measure beneficiaries profile:
The estimates of the probability « benefiting from the measure » are presented in the following table.

| | *Parameters (Standard Deviation)* |
|---|---|
| Age of the firm manager | N.S |
| *Education standard* | |
| Less than A-level | -2.92 ( 0.84) |
| A-level | Reference |
| From A-level to 2nd year of college | -3.12 (0.95) |
| At least end of college | -2.41 ( 0.93) |
| Nb of salaried employees of the firm | 0.068 (0.03) |
| *Turnover during study time* | |
| increasing | N.S |
| stable | Reference |
| decreasing | N.S |
| The firm manager tells he is well-informed about this assistance. | 2.02 (0.45) |

*Table 1:* Probability of « benefiting from the measure »

The results of this model show a wide similarity between estimated and observed variables: the estimated probabilities fit to the observed choices for more than 87% of the sample. It mainly shows a good adjustment of the model to data.

From this table, we can stress the following matters of fact :
➢ Having a **diploma** higher than the A-level or no diploma at all decreases the probability of getting the subsidy. This probability is respectively divided by 18, 23 and 11, whether the manager does not have the A-level, has a diploma from A-level to the 2nd year of college or has a standard education of college level at least, compared to this probability for a firm whose manager has the A-level as higher diploma.
➢ We can observe a **size-effect** through the influence of the salaried employees number of the firm. Indeed, the positive sign of the parameter linked to this number indicates that a company has a greater chance to benefit from the measure than it employs a great number of persons.
➢ The effect of the **information** has not to be neglected.. We observe that the criterion of the information quantity the head of the firm possess is a key variable to get the grant. The probability of getting the subsidy is seven times more important when the leader of the firm holds a sufficient quantity of information or tells he holds a sufficient quantity of information about this help than when he does not.

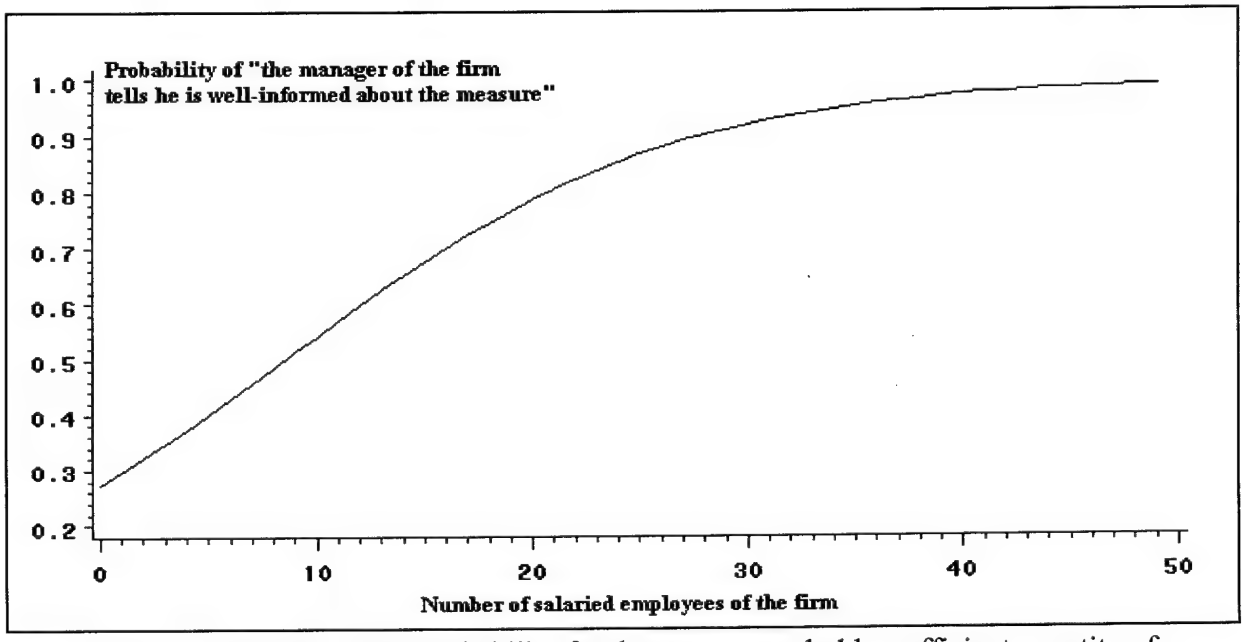
Results are not basically different when an estimate on each sample of firms, i.e. on public A and on public B, is done. We have then to model a variable of Y coded on three positions: the company benefits from the measure and it is an A type firm, benefits from the measure and it is a B type firm, does not benefit from the measure. Typically we are then within the scope of the economic evaluation with a prescriptive aim. The announced objective of this study was to better know the beneficiaries of the measure in order to modify the criteria of attribution. With this partial conclusion about the absence of distinction between the two public, we can bring brief replies, even if the ultimate decision is still a political one. Indeed this study allows to show that the populations concerned by this measure are not the targeted ones, what is particularly true for the A group, composed of growing companies. Saying that the rebate is never used to implement firms' expansion would not be too hard. It helps companies which

are facing difficulties but does not reach a population of efficient firms, which are more likely to generate dynamic local structuring.

Information and targeted firms:
The significance of the quantity of information held by the manager of the firm criterion was previously highlighted. In order to be more precise, we estimated a model that allows to identify the explicative variables of the quantity of information held. The model fits correctly to data but, as we will see further, the construction of this variable is not completely satisfactory. The results of the estimation are not presented here, only is a possible use of the figures (See graph 1).
This model enlightens **the size-effect of the company on the information quantity held by the entrepreneur**. The probability of being informed (P) was deduced from the following selection equation :

$$Log\frac{P}{1-P} = 0.1141\text{EMPL}$$

where EMPL represents the number of workers in the firm.




*Graph 1:* Variation of the probability for the manager to hold a sufficient quantity of information about the measure.

To evaluate the level of information, we only used the manager' own appreciation without measuring the quantity of really acquired information to not make more complex an already thick questionnaire. The treatment of these answers permits to conclude that even if the effect of the size on information is decreasing[12], passing from one to ten salaried employees doubles probability of being informed. This means that for most of the small firms, supposed to be at the origin of growth in most regions, the access to information remains limited.

[12] which only indicates that the size-effect is submitted to a sort of ceiling effect: beyond about thirty employees, the size of the company only influences the acquisition of knowledge on this help by the firm on a marginal way.

Macro-economic effects of the measure:
At this stage of the analysis, we still used a quantitative method that rests upon an equation modeling, on one hand, the probability of turnover increase for a firm and, on other hand, the probability employ new workers over the studied period, conditionally to the fact that this company were supported or not.

The data extracted from the survey realized, did not enable us to detect an influence of the subsidy on the performances of granted companies compared to the not helped ones.

Nevertheless, the analysis of these two criteria -turnover and job creation- allows to foresee the effects of this measure on the whole economy. No effect of the assistance could be highlighted as shown in table 2 below.

| | ***Increase of turnover*** | Job creation |
|---|---|---|
| | *Parameters (St. Dev)* | *Parameters (St. Dev)* |
| **The firm got the subsidy** | **N.S** | **N.S** |
| Age of the firm manager | -0.06 (0.03) | N.S |
| *Education standard* | | |
| Less than A-level | N.S | N.S |
| A-level | Reference | Reference |
| From A-level to 2nd year of college | N.S | N.S |
| At least end of college | N.S | N.S |
| Nb of salaried employees of the firm | N.S | N.S |
| *Turnover during study time* | | |
| increasing | **Not relevant : endogenous variable** | 1.04 (0.42) |
| stable | | Reference |
| decreasing | | N.S |
| The firm manager tells he is well-informed about this assistance. | N.S | 0.39 (0.16) |

*Table 2:* Probability of having good economic indicators, whether the firm benefited from the measure or not.

The table 2 shows that the parameter linked to the variable « got the subsidy » is not really significant. This means that, on the basis of available data, one can consider that **the measure had no effect** neither on job creation nor on turnover. No correlation was find between the fact « turnover increase » over the studied period and the event « has got a subsidy ».

Econometric methods used, know for their usefulness when one has to establish a correlation between some events, permit us to highlight the following characteristics elements:
➢ The probability of benefiting from an interest rate rebate depends more on the information held by the manager of the firm than on the own characteristics of the company.
➢ The bigger the requesting company is, the more it is likely to benefit from the measure.
➢ The funded companies profiles studied with balance sheets indicators are similar whatever reason the interest rate rebate is got (weak differences between A type and B type firms)
➢ This subsidy does not have a significant effect on the commercial positioning of the companies approximate using a turnover criterion.
➢ This measure does not have a significant effect on the process of creation or maintenance of employment in the companies.

**Monetary policy applications**

The question of the growth and the economic development deals firstly with net investment, entrepreneurship and firms' development. Since all these elements refers to private consideration, it is from private sector it became usual to depart from to design instruments of public intervention. This "bottom-up" approach found the interest rate rebate previously evaluated. Before drawing some general conclusions about the implementation of an economic measure, let us firstly comment the efficiency of the studied interest rebate.

Three questions motivate the realization of the study :

Up to what point can the private firms contribute to the economic development?

What kind of public organizations may intervene ?

What role for the Public authorities?

According to the studied measure, it is possible to bring the following brief replies:

The firms play an essential role in the development in the economic area considered since they profit from a system of assistance and grants to improve their performances in order to optimize their growth

The growth policy rests on the creation of ad hoc institutions among which the organization charged to carry out the funds allocation plays a crucial role

The Public Authorities occupy an essential place in the process of arbitrage between consumption and investment and resources allocation. Interest rate rebates constitute then a mode of intervention simultaneously direct (influencing the industrial and financial choices within firms) and indirect (influencing the conditions observed on the credit market).

However, funding firms constitutes only one option of economic policy. One can even consider that the increase of the available subsidies and of the amounts devoted to these economic actions seem to induce a spurious effect. Instead of considering the grants are incentives that aim at changing their firm's behavior, entrepreneurs consider public funds as free financial resources that appear at the first rank in the implicit financial pecking order. In that sense, the Agency in charge of subsidies compete with banks and other suppliers of funds such as potential shareholders on an enlarged financial resources market. This interpretation is directly related to the grant whose evaluation is done here, probably because it explicitly takes part in the financial restructuring of the firm, without any reference to a precise project of investment or development. This is what distinguish such a subsidy from an incentive contract whose terms are such as from the results of the first period depend the conditions proposed over the second one. Short term renewable contracts induce an important change in the relationship between entrepreneurs and grant supplier : instead of being considered as a due providing that administrative requirements are respected, the subsidy becomes conditional to the realization of some negotiated results, so that the public authority becomes an "hands on" partner.

This observation is very close from of the what has been noticed about the limits of the system of direct subsidies implemented in most European regions: the multiplication of the grants induces not only a direct cost equal to the distributed amounts but also of an indirect cost coming from the functioning of the system and the time that the potential recipients must spend to understand what they can demand for. From this observation result two questions about, on one hand, the role of information in the implementation of economic policies which rest then on announcement effects and, on the other hand, on the evaluation of the structuring capacity of subsidies proposed. It is on this last point we wanted to insist on insofar as it seems that making an *ex ante* evaluation would have allow to solve the question of the potential macroeconomic or spill-over effects of the grants.

It is then possible that, in accordance with the results of the studies on evaluation already realized, a kind of mirroring between the probability of being supported and the effects of the subsidy would have been observed. Indeed, the Public Authorities support more easily the more powerful firms and the granted firms are more powerful than the others. An *ex ante* evaluation of the studied rebate would have allow to detect this effect and would have thus avoided devoting public funds to operations which does not contribute to the realization of the expected effects.

As a tool at disposal of the public policy makers, the economic evaluation is not an instrument devoted to judge the quality of the public welfare chosen by the politicians but rather allows to estimate the capacity of an economic action to contribute to the achievement of an aim collectively considered as desirable. For this purpose, it is important to center the analysis on three elements that characterize the relationship between the independent variable, the instrument, and the dependent variable, the target, that are :
the **relevance** of the action according to the objective function of the targeted groups,
its **consistency** or, in other words, the homogeneity of all its components which insures the rational and efficient use of public funds,
its **performance** which depends on the gap between the initial situation, the expected final one and the observed results.

The engagement of the decision makers in such means of action is the price to pay to identify the most efficient economic actions and policies, to adjust costly and ineffective systems and, at last, to rank problems according to an adequate level of organization.

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# Design and validation of ATM network architecture: a discrete event modeling and simulation approach

E. De Gentili, F. Bernardi, J.F. Santucci
University of Corsica, URA CNRS 2053 SPE
Quartier Grossetti, 20250 Corte,
France
E-mail : {gentili, bernardi, santucci}@univ-corse.fr

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Model design, Event-oriented, Object-oriented, Hierarchical, Computer networks.

## ABSTRACT

The dramatic increasing demand in telematic services involves some huge problems in network designs. Using fast and powerful simulation tools is the best way to solve these problems and to try to fit with increasingly severe economical criteria. We present in this paper our work based upon the discrete event modeling and simulation technique. Our goal is to include the concepts of multiview and abstraction in order to define a generic software framework for telecommunication simulation. This generic software should be able to provide an unique and system independent simulation technique, coupled with a powerful object oriented library of telecommunication components. The theoretical paradigms presented in this paper are applied to an ATM switch for modeling, simulation and validation.

## INTRODUCTION

There is an increasing demand for advanced telematic services (Robles 1994) supporting features as mobility, real-time multimedia and also bi-directional broadband access. This implies a need of high speed network and, therefore, a dramatic increasing complexity of some networking protocols, wich are not only confined to the lowest layers of the OSI protocol stack (as ATM-based systems are). Examples are fast context switching, selective buffering, timer management, and also presentation functions as audio or video for multipoint multimedia. Performance issues should also be supported during the various stages of the network design (fast context switching, VPI/VCI selective buffering in ATM systems (Fahmy 1998)).

Besides, the dramatic development that communication networks are experiencing involves a great increase, not only in the functionality, but also in the complexity of network elements (Black and Cros 1993). This has impact on the tools supporting the design, as well as the specification methods that are used.

The general problem to be solved is the following : Providing a generic software structure enough adaptable to deal with very different kind of complex systems involved in telecommunication applications.

This generic software should be able to take into account :

- all the particularities of the studied system
- a unique and system independent simulation technique
- a multi-level modeling and simulation approach (depending on the studied problem, the simulation should be performed at various abstraction levels)
- the structure and the behavior of the studied system (when the structure is known and helpful for the simulation)

- the development and use of a powerful object oriented library of components (allowing the reusability of basic components)

In this paper, we present the first stages of our work : the development of a generic modeling and simulation approach, and its application to a complex element involved in an ATM network.

## STATE OF THE ART

Computer simulation is the creation and execution of dynamical models employed for understanding a system behavior. This problem of modeling and simulation of complex systems is studied very carefully by researchers and industrials all over the world, and two kinds of axis have been developed and now jointly used :

- the Object Oriented Programming (OOP) Approach (Gensel 1995)
- the Discrete Event Simulation (DES) technique (Zeigler 1976), (Zeigler 1984), (Elzas et al. 1989)

For the fundamental building primitives (comprising models representing a time-dependent system behavior), system theory provide the most mathematically consistent foundation.

The first formal theories for discrete event simulation were based upon system theories but, however, there is a lack of system theoretic formalism in object oriented concepts and software engineering paradigms.

Within the classical system theory, a deterministic system $< T, X, Y, S, \delta int, \delta ext, \lambda, t_a >$ is defined as follows :

- T : time set
- X : input set containing the possible values of the system inputs
- Y : output set
- S : state set
- $\delta int$ : internal transition function
- $\delta ext$ : external transition function
- $\lambda$ : output function
- $t_a$ : time advancing function

The basic concepts in this formalism are : (i) the notion of states and (ii) the notion of events.

From this basic definition, different techniques have been defined and employed in order to make the overall system modeling scheme more manageable :

- level coupling
- hierarchy implementation
- inter-level coupling

Furthermore, the linking between Object Oriented Paradigms and the previous formalism has leaded to the definition of Object Oriented Modeling and Simulation (Zeigler 1980).

We think that the research should integrate in the future :

- the notion of structural and behavioral view, since now only the behavioral view is used for performing simulations,
- a real use of hierarchies (timing (Euzenat 1994), abstraction (Oussalah et al. 1995) and description hierarchies (Aiello et al. 1996)), since now only the description hierarchy is used in the works mentioned before (unfortunately, this kind of hierarchy is a very simplistic one),
- a clear definition of the automatic generation of the simulation algorithms associated to a given model,
- the definition of an efficient infrastructure for an Object Oriented Library which will be used at different levels of abstraction and different views.

Integration of the four previous concepts are very adapted for the framework of the design of Telecommunication Networks :

(i) the use of hierarchy notions will allow, for instance, to perform the simulation of such a network at different hierarchy levels depending on the required details

(ii) the multiview notion will allow to take into account the potential structure of a telecommunication network to be designed when performing the simulation of validation scenarios,

(iii) the definition of a telecommunication architecture model will be facilitated by using a powerful library of components.

## THE ATM SWITCH

An ATM switch is a physical and logical network element allowing ATM cells transport from source to destination using routing informations encapsulated in cell headers.

The communication is performed through I/O ports coupled to waiting queues and using two main procedures :

- definition of two connection identificators,
- creation and management of routing tables giving correspondences between all I/O ports.

These procedures are associated with a queues management and a cell header updating mechanism.

## DISCRETE EVENT MODELING OF THE ATM SWITCH

Our modeling work occurs at the ATM layer of the ATM reference model, through a hierarchical discrete event approach.

The modeling diagram is described in Figure 1:

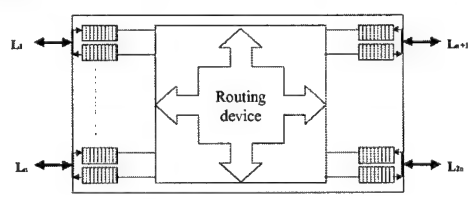


*Figure 1 : Modeling diagram of the ATM switch*

Our model is able to deal with the following problems :

- cells routing,
- minimal congestion control based upon the CLP=1 cells and upon a possible traffic slowdown,
- connection demands management (considering signaling cells),
- QoS and connection classes management,
- Established connections management using routing tables,
- Internal traffic management using buffered memories.

### Descriptive variables

The mainly used descriptive variables are (considering n I/O ports) : 2n routing tables, 4n waiting queues and QoSAvail[2n], an array giving the available QoS on each port.

### Functions

δext, the external transition function, manages cells stocking in queues.

δint, the internal transition function, manages queues congestion, availability of QoS, connections establishment or breakdown, cells headers and routing tables updating.

λ, the output function reads the queues and sends concerned cells through the concerned transmission port.

## OBTAINED RESULTS

The diagram given in Figure 2 shows the evolution of a queue deliberately flushed with cells :

This example shows up the filling steps and the deletion of cells caused by queues congestion.

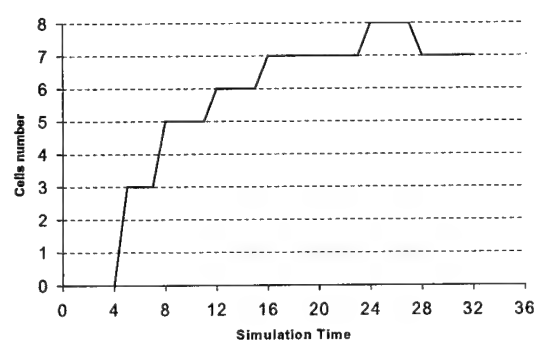


*Figure 2 : Evolution of cell number in a queue*

## CONCLUSION AND FUTURE WORKS

In this paper, we have presented how generic concepts of Discrete Event Modeling and Simulation could be applied for studying telecommunication networks. A real case example has been developed for validating this approach.

Our short term research concerns:

- The development of a complete and powerful modeling and simulation approach of telecommunication networks specifications in order to select the "best" architecture before implementation. This approach is based on multiview modeling and simulation at different levels of abstraction of the components involved in a given telecommunication architecture.
- The development of an object oriented library allowing the reusability of the base elements involved in the modeling of such architectures.

The long term expected results are the following :

- a generic software framework allowing the modeling and the simulation of different kinds of complex systems,
- the validation of the framework based on the implication of four kinds of users :

  - FB : the Framework Builder, specialist of Computer Sciences, in charge of the design of the generic framework software,

  - AB : the Application Builder, specialist of a given problem, not necessarily competent in Computer Sciences (for instance, commercial people),

  - FU : the Final User, interested in solving a given problem using a simulation approach,

  - LB : the Library Builder, specialist in Computer Sciences, in charge with the definition of an efficient infrastructure for the Object Oriented Library used by other users.

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# An object oriented environment applied to the fire spread across a fuel bed under local wind condition

T. MARCELLI, A. AIELLO, P.A. SANTONI, J.H. BALBI,

***Université de Corse - SPE -URA CNRS 2053, B.P. 52, Campus Grossetti, 20250 Corti***

Tél. 04-95-45-00-73 Fax. 04-95-61-05-51

Email : {marcelli, aiello, santoni, balbi}@univ-corse.fr

## ABSTRACT

This paper presents the second stage of our general aim : an application of an object oriented environment to the fire spread across a fuel bed problem under local wind condition. In a first place, we describe the physical process and the existing models. Then we set out the interests of the object oriented approach for the study of our fire spread model. We explain the fundamental concepts of this approach which are applied to the considered problem. The constitutive elements of the object oriented model and simulator are detailed. Finally, the advantages and the evolutions of the proposed approach are discussed.

*Keywords* : modelling, hierarchy, simulation, object oriented methodology, fire spread, local wind.

## Introduction

Over the last fifty years, a certain amount of interest in the modelling of forest fire spread has been generated within the scientific community [Rot72, Alb85]. The problem consists of calculating the fire spread rate, flame front position and temperature distribution in a fuel complex.

The aim of our research team is to create a simulator, which is capable of describing the spread of a forest fire in order to help fire fighters. To this end, the simulator developed must be characterised by a short calculation time. This necessitates a simple model capable of predicting the key features of a fire.

In a previous study [Bal98], we have developed such a model under no wind condition. Those works aimed on experimental fire modelling ($1m^2$) [Dup95]. Despite the good results, the developed code proved complex, and showed some problems related to the evolutions of the fire spread model [San98]. To circumvent those difficulties, we have used an object oriented approach [Aie98]. In this paper, this approach is used to face to an evolution of the physical fire spread model devoted to take into account the wind influence. To this end, we are based on the work presented at Nîmes [Aie98].

This leads us to use a modelling and a simulation general environment [Aie96a, Aie96b]. This environment [Aie97a, Aie97b] proposes a set of tools which intend to make easier the creation and the simulation of evolving models. The originality of this approach takes place on one hand, in the hierarchical and discrete events modelling formalisms combination, and on the other hand in the object oriented programmation's concepts implementation during the realisation step.

The first stage of this paper presents the forest fire spread physical models. We expose the difficulties due to their simulation. The modelling and the object oriented simulation concepts are explained in the second stage. Then, we present in the third stage the object oriented model simulator. Finally, we conclude this work with a discussion about the advantages of the proposed approach.

## I – Forest fires : position of the problem and wind effects

*Phenomenon description and existing models*

During a forest fire, the fuel matter located ahead of the fire front is heated and releases combustible gaseous products. The following oxidation of those gases produces a spreading flame. The surface between the combustion zone and the inert zone is called "the ignition interface". Fire spread models are predicting the rate of this surface. There are on one hand the *fundamentals* models [Gri97] which use the conservation equations in both gaseous and solid phases, and on the other hand the phenomenological models [Web91, Alb85, Bal98] which characterise the spreading by only one equation.

In the view of elaborating a real time simulator, we have developed a phenomenological model [Bal98]. Indeed, facing with the important data volume to take into account, it is necessary to have a simple model doing a globalisation of the phenomena. The previous study was concerned with actual forest fire. Indeed, before modelling great scale fire, we must determinate the influence of the mechanisms involved in fire spread. To this end, we have in a first stage modelled fire spread across fuel bed thanks to experimental data provided by the INRA of Avignon [Dup95].

*Hypotheses and physical model*

**An equivalent medium**. The present study uses elementary cells composed of earth and plant matter. As a whole, these experimental cells are considered to represent a thin, isotropic, and homogeneous equivalent medium.

**Exchanges with the surrounding environment**. The energy transferred from the cell to the surrounding air is considered to be proportional to the difference between the temperature of a cell and the ambient temperature.

**Equivalent diffusion**. Heat transferred between a cell an its neighbouring cells is due to three mechanisms : radiation, convection, and conduction. We assume that these exchanges can be represented by a single equivalent diffusion term.

**Equivalent kinetics**. To model the combustion reaction, it is assumed that (1) combustion occurs above a threshold temperature $T_{ig}$, (2) above this threshold, the fuel mass decreases exponentially, and (3) the quantity of heat generated by the combustion reaction per unit fuel mass is constant.

*Wind modelling*

The experimental observation shows that the wind flow, near the surface, can be split up in two zones :

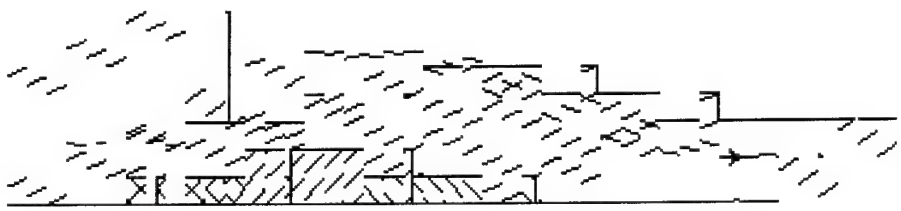
a boundary layer near the solid surfaces in which the viscous forces play an important role,

an domain out of the boundary layer in which the moving fluid can be considering like inviscid fluid.

In the boundary layer, the wind profile is given by the logarithmic law of Prandtl [Pla64]. At the boundary layer external limit, the velocity tends towards a finite value which is approximately the wind velocity far from the surface (about 99% of this value).

For the simulator, we take place over this boundary layer with the intention of having a model as simple as possible [Mar98]. This model gives the wind flow representation in two dimensions. In this way, we can determinate the wind flow over the vegetation. Since the wind flow velocity in the boundary layer is lower than the external one we get an overestimation of the wind effects on the fire spread.

*Figure 1 : Determination of the wind velocity over the boundary layer of a vegetation*



Fire spread model

$$\frac{\partial T}{\partial t} = -k(T - T_a) + K\Delta T - Q\frac{\partial \sigma_v}{\partial t} + \mathrm{R}(\vec{v}) \text{ in the domain} \quad (1a)$$

$$\frac{\partial \sigma_v}{\partial t} = 0 \quad \text{for an inert cell} \quad (1b)$$

$$\frac{\partial \sigma_v}{\partial t} = -\alpha\sigma_v \quad \text{for an burning cell} \quad (1c)$$

$T(x,y,t) = T_a$ at the boundary (1d)

$T(x,y,0) = T_a$ for the non burning cells at $t=0$ (1e)

$T(x,y,0) = T_{ig}$ for the burning cells at $t=0$ (1f)

The model parameters are identified from experimental data of temperature versus time [Bal98].

*Numerical study*

The study domain is meshed uniformly. The physical model is solved by the finite differences method which leads to the following algebraic equation :

$$aT_{i,j}^{k+1} = bT_{i-1,j}^{k} + bT_{i+1,j}^{k} + cT_{i,j-1}^{k} + cT_{i,j+1}^{k} + Q\left(\frac{\partial \sigma_v}{\partial t}\right)_{i,j}^{k+1} + dT_{i,j}^{k} + P(\vec{v}).\left(T_{i,j-1}^{k}\right)^4 \quad (2)$$

where $T_{ij}$ is the temperature of a grid node. The coefficients $a$, $b$, $c$ and $d$ depend on the considered time step and mesh size [Bal98].

## II – Hierarchical modelling and object oriented simulation

The old developed code could not take into account easily the evolutions of the model (wind influence, non-homogenous vegetation, slope influence) [San98]. To carry out those difficulties we have treated the problem with an object oriented method [Aie98]. This approach sets out a hierarchical modelling associated to a discrete events concept. The aim is to develop a set of tools intended to facilitate the creation and the simulation of evolving models. This approach lets us to consider the evolution of the fire spread model presented previously which concerns the wind effects.

***Modelling***

The formalism used to specify the different models which are in our environment is presented in our previous work [Aie98]. It allows to take into account the different aspects of the studied system, in a modular and hierarchical way. Only the concepts linked to the behavioural aspect which intervenes directly in the fire spread model elaboration are presented here. The main elements required to make use of our model are the following :

• **Atomic models** which give a local description of the dynamical behaviour of the studied problem.

• **Composition models** which represent the different interconnections between a set of model elements (atomic models or other composition models).

A composition model describes how to connect many elements in a hierarchical way to obtain a larger model (hierarchy of description)

*Simulation*

The components of a specific model are used to automatically generated the corresponding simulator. Three kinds of simulation elements has been defined : the main-coordinators, the coordinators and the simulators.

The Simulators and Coordinators are respectively in charge of managing the atomic models and the composition models. Every atomic model is linked to its simulator and each composition model is linked to its coordinator. The Main-Coordinator manages whole the simulation process and is linked to the coordinator of the larger composition model (*i.e.* representing whole the system).

On the figure 2, we present the general architecture of the different classes which allows to define all the components previously introduced. The main class (Entities) gives the general functions such as the objects construction and destruction. All the simulation model classes are derived from this class. The Models class gives the basic tools to be useful to modelling. The Atomic-Models and the Composition-Models classes are specialisation of the Models class. The Processors class gives the main characteristics of the components used to perform the simulation progress. The Simulators, Coordinators and Main-Coordinators are specialisation's Processors class.

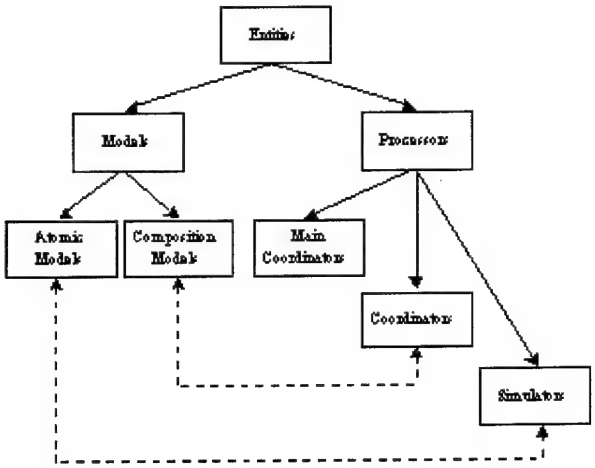


Figure 2: Hierarchy of classes

To simulate a particular model, we have to, on one hand, instanciate the atomic models and the composition models which are constituting this model, and on the other hand generate :

• for each atomic model instance, an instance of the Simulators class ;
• for each composition model instance, an instance of the Coordinators class;
• an instance of the Main-Coordinator.

The relationship of the set of those elements forms a "simulation tree".

*The simulation process*

The simulation is performed by using different kinds of messages exchanged between processors (simulators, coordinators and main-coordinator). Those messages contain the informations describing the events to treat during the simulation.

Four kinds of messages allow to realise the simulation :

the "*" messages associated to the internal transitions ;
the "x" messages associated to the external transitions ;
the "y" messages associated to the output functions ;
the "d" messages associated to the simulation process synchronisation.

In the following section, we apply all the previous concepts to the study of the forest fire spread.

## III – Object oriented approach application to the forest fire spread under wind condition

*Modelling*

**In order to have a better understanding of the present work, we propose to do a come back on the numerical study of the physical problem which leads us to the model and object oriented simulator elaboration.**

The numerical resolution which needs to mesh the spread domain (Fig. 3) leads naturally to define the atomic models (C elements) associated to the cells which are constituting the mesh.

| | | |
|---|---|---|
| C_1 | C_2 | C_3 |
| C_4 | C_5 | C_6 |
| C_7 | C_8 | C_9 |

*Figure 3 : example of a spread domain mesh*

The example shown in figure 3 gives rise to the following behavioural model :

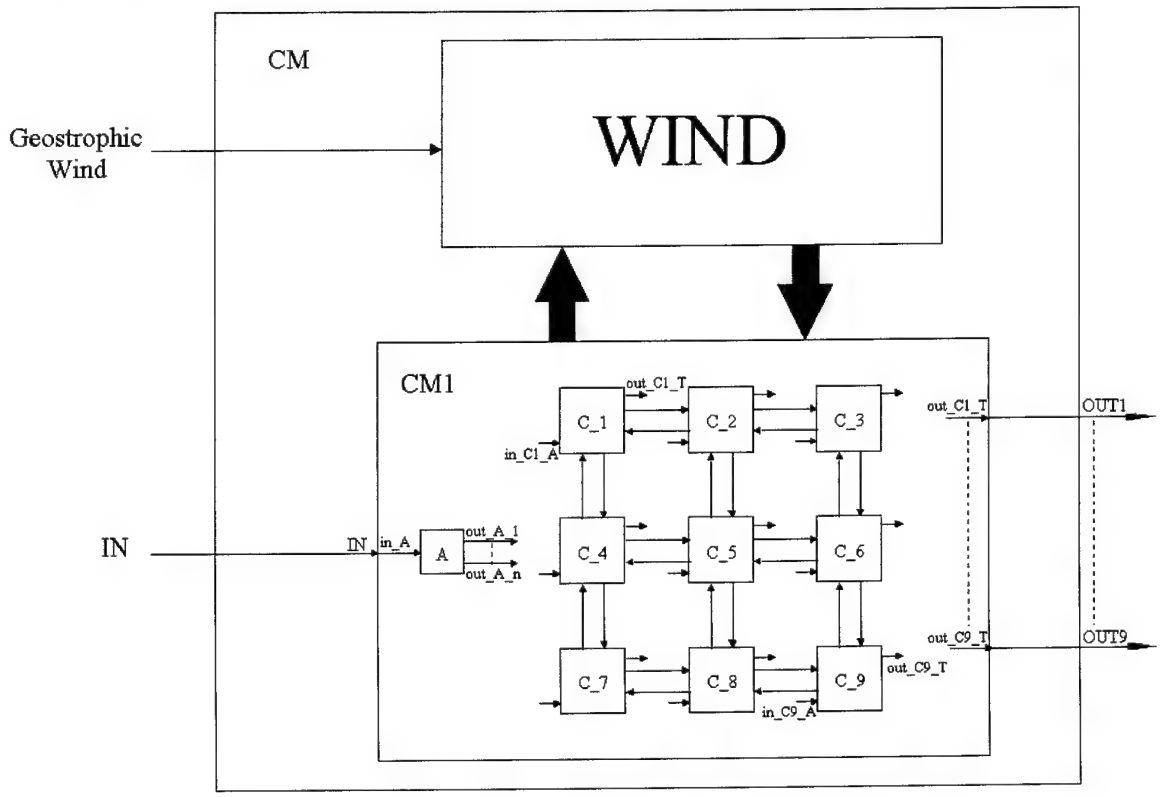



*Figure 4 : Fire spread object oriented model*

Each C elements on figure 4 is linked to the neighbour elements. Those links allow to take into account the thermal exchanges between the different cells. Only the cells located to the spread domain boundary have a limited number of links because they represent the problem interaction with the external middle. The A element is directly linked to the C elements. It allows to initiate the fire spread in specifying the ignition zone.

An A element owns a input port (in_A) through the one the data which allow to determine the ignition place are received, as well as a set of output ports (out_A_1 à out_A_n) which are corresponding to the C elements number. This component allows to request only the concerned elements by the ignition.

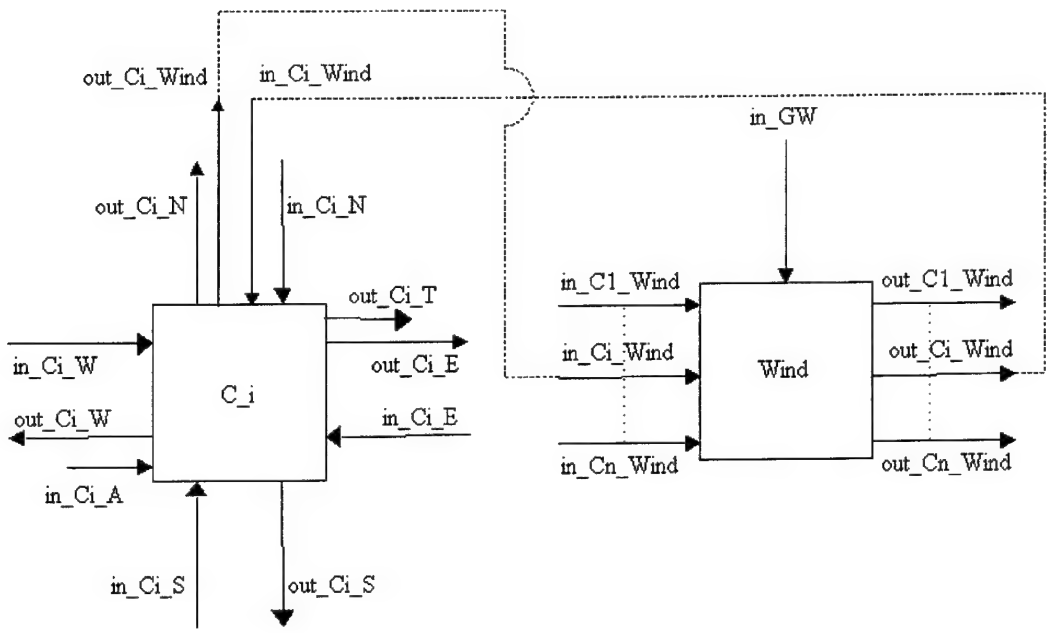



*Figure 5 : C elements details with the links to the Wind Model*

The C elements (Fig. 5) are defined by the following characteristics :

• Four input ports and four output ports allow the information exchange between the element and its neighbours :

| | |
|---|---|
| • in_C_N | • out_C_N |
| • in_C_S | • out _C_S |
| • in_C_E | • out _C_E |
| • in_C_W | • out _C_W |

Let remark that all those ports are not informed of a boundary element.

• An input port is used for the element ignition : in_C_A.

• An output port gives the temperature value of the element : out_C_T.

• One input port (in_Ci_Wind) and one output port (out_Ci_Wind) allow the exchange between the element and the Wind Model.

*Simulation*

The model introduced previously (Fig. 4) gives rise to the automatic generation of the following simulation tree :

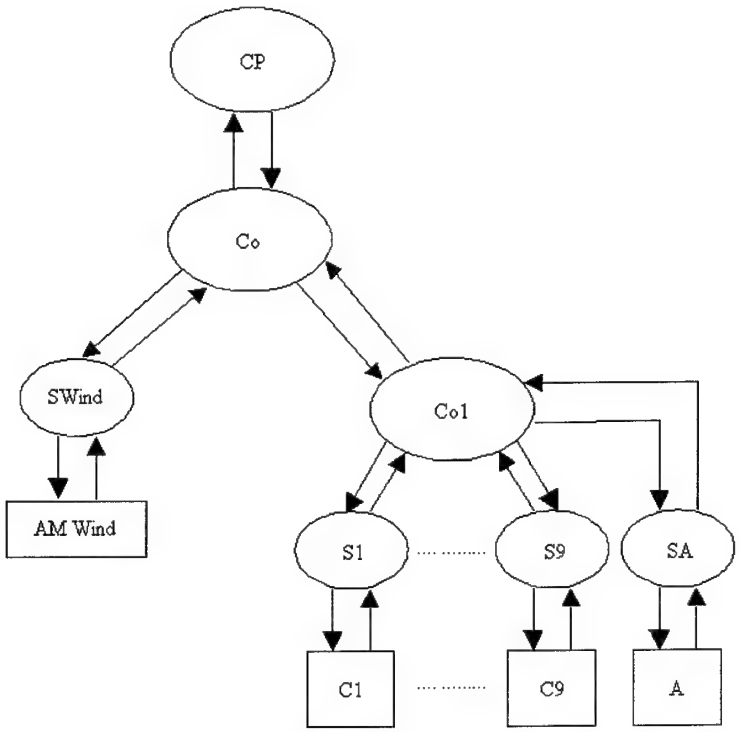



*Figure 6 : Object oriented simulator associated to fire spread model*

The Main-Coordinator (CP) manages whole the simulation process (input data reading, results writing, simulation step time management). The Coordinator (Co) allows to synchronise the messages exchange process between Swind simulator and Co1 coordinator which respectively control AM Wind and CM1 components. Co1 manages the exchanges between the simulators SA, S1,S2,..., S9. Those lasts handle A,C1,C2,..., C9 atomic models.

So for example, the one mesh cell ignition is represented by an incoming 'x' message on the atomic model in_C_A port where C represents one cell. This message send by the associated simulator S, leads to the C external transition function □ext execution, which the role is to calculate the cell temperature from the neighbour cells temperature and from the wind velocity (eq. 1a). The output function □ sends a 'y' message containing a result to the Coordinator Co1. Finally, this value is passed on by Co to Main-Coordinator CP.

## Discussion and Conclusion

This work proposes an approach modelling and object oriented simulation applied to the behavioural study of a forest fire spread. The main contribution of this study is concerned with the possibility to take into account easily the physical model behavioural evolutions. For example, for the wind effects on fire behaviour which have conducted to a modification of our fire spread model, this object oriented approach has revealed its advantages. In the same way, we will introduce in the proposed simulation model modifications linked to the fuel nature, to the slope influence.

Indeed, in the non-homogenous vegetation case, the spread equation coefficients values are modified. Those variations will be taken into account by a simple modification of the parameters associated to the atomic components functions.

With regard to the slope effects, an another term linked to the radiation is introduced in the physical fire spread model [San98]. The influence on this one would be directly represented within the atomic components δδext et functions.

The concepts linked to the object oriented programmation give us the possibility to do a modular validations serie, warranting the creation of a sturdy and efficient modelling and simulation tool.

We project to deal with the creation of a library of specific components in order to facilitate the fire spread model construction.

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# Utilization of an optimal control method for the numerical determination of boundary conditions in open sea

F. Bosseur[13]

## 1. INTRODUCTION

Though experimental measurements represent the basic method of scientific research, they are indissociable from the experiences conditions. Then, they could not permit any predictions in space and time. This probably leads the scientifics to elaborate the models.

Nevertheless, however complete the models can be, they are not always able to account for the reality, considering the extreme complexity of the studied problems. Then appear the question of the indetermination, inevitably linked to the models: on the one hand, the models could only take into account a limited number of parameters (structural indeterminations), on the other hand, since the external terms and the auxiliary conditions – as initial or boundary conditions – are approximately known (statistical indeterminations).

Then appear the necessity to use jointly observations and mathematical models: it's with this aim in view that has been developed the so called *data assimilation method*. This one progressively stands out as an unavoidable alternative in number of domains such as, for example, meteorological prediction, in which, it has permits substantial developments.

The application of this kind of method to the oceanography is relatively recent. It has mainly been justified by the necessity to remove at best the statistical indeterminations which characterize the partial differential equations problems associated to marine models. In fact, though the knowledge of initial and boundary conditions is primordial since it's the guarantor of a successful connection between the modelized system and the outside world, it's not usually well-known. At first for logistical reasons but as well for consistent reasons towards the model, particularly the spatio-temporal discretization of the domain (dimension of the grid, integration time step).

In this work, we study a two-dimensional shallow water model which is obtained by integrating the three-dimensional equations over the depth. In the case of a well-mixed sea, this model is proved sufficient in order to represent the flow dynamic and can constitute a previous stage to a more extensive study by a three-dimensional model. Moreover, this one can be considerate as the "core" of the vertically integrated equations of the three-dimensional model. The phenomena represented by these equations are implicitly include in the global model and they appear at the time of the decomposition in external and internal mode, generally applied during the utilization of time spitting method. Some theoretical and numerical studies has been done on this model (ORENGA, 1992 ; CHATELON–ORENGA, 1997 ; BISGAMBIGLIA, 1989).

We suggest to study the case of open sea domains where is often posed the problem of the acquaintance of velocity and elevation boundary conditions. These ones are generally

13 Université de Corse – Pascal Paoli, SPE – URA CNRS 2053, Campus Grossetti, BP 52, 20250 Corte ; e-mail: bosseur@univ-corse.fr

evaluated thanks to experimental data – stem from measurements campaigns – or calculated data resulted from a larger scale model.

In the case of the bay of Calvi, some *in situ* measurements has been carried out (NORRO, 1995), thanks to the vicinity of the oceanographic research station STARESO. Nevertheless, these ones are in insufficient number and give few information about boundary conditions in open sea. In the same way, results stem from research program like Medalpex can not take into account phenomena occurring at a bay scale. With intend to remove these difficulties and to use at best the available measurements, we propose to use data acquisition methods.

The control is made on the velocity boundary condition on open boundaries, in considering observations at isolated points. The problem is solved by the Galerkin method.

In section 2., we briefly present the equations of the model. In section 3., we give the adjoint model and a critical extremum condition. Section 4. and 5. are consecrated to the numerical analysis of the equation and to the numerical method used. Finally, we present in section 6. some numerical results obtained in the real situation of the bay of Calvi, where one can note coastal erosion phenomena mainly due to the modification of the flow after the establishment of structures in sea (extension of the port, ...).

## 2. PRESENTATION OF THE MODEL – NOTATIONS

In a global oceanic model, biochemical and hydrodynamic variables are taking into account; here, we only study the hydrodynamic variables of the system.

In order to describe the evolution of these variables, we use geophysical fluid mechanics models which differ from standard problems of flow such as Navier-Stokes one, by the dimensions of the domains, the temporal scales, the continuity equation, the shallow depth and particularly the boundary conditions.

The three-dimensional model is obtained from the basic conservation laws equations by applying some simplifying hypothesis. On the one hand, the small dimensions of the domain under study in comparison with earth's radius allow us to use a Cartesian coordinates system. On the other hand, the Boussinesq hypothesis allows to neglect the variations in fluid density, except for the pressure gradient term.

The shallow-water equations used in this paper are obtained by integrating the equations of the three-dimensional model over the depth, by supposing a well-mixed fluid.

Let $\Omega$ be a fixed bounded smooth open domain of $\vec{u}^2$, with boundary $\gamma$ ; $x=(x_1,x_2)$, represents a point of $\Omega$ and $n$, is the exterior normal of $\gamma$. The boundary is decomposed in two parts:

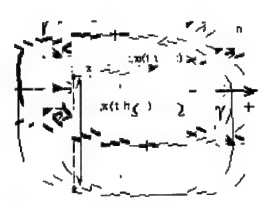

Fig. 2.1: *Study domain*

- $\gamma_f$, the coasts ($u.n=0$),
- $\gamma_e$, the open boundary ($u.n=G(x,t)$).

Moreover, we denote by $\gamma^-$ (resp. $\gamma^+$) the part of the boundary where the flow enters (resp. is outgoing). This differentiation is justified by the necessity to fix the water elevation on the part of the boundary where the flow enters (CHATELON–ORENGA, 1997). Then, we set

$$Q = \Omega \times ]0,T[, \quad \Sigma = \gamma \times ]0,T[, \quad \Sigma^+ = \gamma^+ \times ]0,T[, \quad \Sigma^- = \gamma^- \times ]0,T[.$$

If $u=(u_1,u_2)$ is a vector function from $\Omega$ into ú$^2$ and $q$ a scalar function from $\Omega$ into ú, we define the following operators $\alpha$, curl, Curl as follows

$$\alpha(u) = \begin{pmatrix} -u_2 \\ u_1 \end{pmatrix}, \quad \operatorname{curl} u = \frac{\partial u_2}{\partial x_1} - \frac{\partial u_1}{\partial x_2}, \quad \operatorname{Curl} q = \begin{pmatrix} \dfrac{\partial q}{\partial x_2} \\ -\dfrac{\partial q}{\partial x_1} \end{pmatrix}.$$

The equations of the *shallow water* problem are the following

$$\begin{cases} \dfrac{\partial u}{\partial t} - A\Delta u + \dfrac{1}{2}\nabla u^2 + \operatorname{curl} u\alpha(u) + \omega\alpha(u) + Du|u| + \nabla q = f, & \text{in } Q, \\ u.n = G(x,t), & \text{on } \Sigma, \\ \operatorname{curl} u = 0, & \text{on } \Sigma, \\ u(t=0) = u_0(x), & \text{in } \Omega, \\ \\ \dfrac{\partial h}{\partial t} + \operatorname{div}(uh) = 0, & \text{in } Q, \\ h = \mu(x,t), & \text{on } \Sigma^-, \\ h(t=0) = h_0(x), & \text{in } \Omega. \end{cases} \tag{2.1}$$

For the numerical resolution of the equations, and especially to use the special basis intervening in the Galerkin method, we have to transform the equations in order to obtain an homogeneous problem.

So, we set $u=v+w$ where $v$ satisfies $v.n=0$ on the boundary and $w$ is such that $w=Lp$, with $p$ solution of

$$(\mathcal{R}) \begin{cases} -\Delta p = 0 & \text{in } \Omega, \\ \dfrac{\partial p}{\partial n} = G & \text{on } \gamma_e, \int_\gamma G d\mathbb{R} = 0. \end{cases} \tag{2.2}$$

Then, we obtain the following problem

$$
(\mathcal{P})\begin{cases}
\dfrac{\partial v}{\partial t} - A\Delta v + \dfrac{1}{2}\nabla v^2 + \mathrm{grad}(v.w) + \mathrm{curl}\, v\alpha(v) + \mathrm{curl}\, v\alpha(w) + \omega\alpha(v) + Dv + g\nabla h = \\
\qquad\qquad f - \dfrac{\partial w}{\partial t} - \dfrac{1}{2}\nabla w^2 - \omega\alpha(w) - Dw, & \text{in } Q, \\
v.n = 0, & \text{on } \Sigma, \\
\mathrm{curl}\, v = 0, & \text{on } \Sigma, \\
v(t=0) = u_0(x) - w(t=0), & \text{in } \Omega, \\
\\
\dfrac{\partial h}{\partial t} + \mathrm{div}\,(vh) = -\mathrm{div}\,(wh), & \text{in } Q, \\
h = \mu(x,t), & \text{on } \Sigma^-, \\
h(t=0) = h_0(x), & \text{in } \Omega.
\end{cases}
$$

(2.3)

## 3. THE ADJOINT MODEL

Reminding that the basic principle of optimal control, is the minimization of a cost function $J$ measuring the difference between the calculated solution and a set of available measurements. In practice, the minimization of $J(w)$ requires the knowledge of the gradient of $J$ with regard to the control variable. Between the different methods of determination of this gradient, the utilization of the adjoint equations of the so called *linear tangent model*[14] seems to be the more interesting numerically (LIONS, 1968; TALAGRAND–COURTIER, 1987).

We consider $x^1,\ldots,x^m$, some points of $\Omega$. Afterwards $m$ is the number of available measurements. By noting the desired state $u_d \in (L^2(\vec{u}))^m$ under the form

$$u_d = \left(u_d\left(x^1\right),\ldots,u_d\left(x^m\right)\right) = \left(u_{d1},\ldots,u_{dm}\right)$$

we define the cost function $J(w)$ by

[14] obtained in differentiating the equations of the model with regard to the control variable.

$$
\begin{aligned}
J(w) &= \left\| C(v+w) - u_d \right\|^2 + \varepsilon \|w\|^2 \\
&= \sum_{j=1}^{m} \int_0^T \left| v(x^j, t; w) + w(x^j) - u_{dj}(t) \right|^2 dt + \varepsilon \|w\|^2
\end{aligned}
$$

where $C$ is the so called *observity* operator, from the state into observations space's.

The adjoint equations are obtained by multiplying the equations of the linear tangent model by the adjoint state functions *(v*,h*)* and by integrating on $Q$. We get the following problem *(P*)*

$$
\left\{
\begin{array}{ll}
-\dfrac{\partial v^*}{\partial t} - A\Delta v^* - v\,\mathrm{div} v^* - w\,\mathrm{div} v^* + \mathrm{Curl}\big(v\alpha(v^*)\big) & \\
\qquad + \mathrm{Curl}\big(w\alpha(v^*)\big) - \mathrm{curl}\, v\alpha(v^*) - h\nabla h^* - \omega\alpha(v^*) + Dv^* & \\
\qquad = \displaystyle\sum_{j=1}^{m} \Big(v(x^j, t; w) + w(x^j) - u_{d_j}(t)\Big) \otimes \delta(x - x^j), & \text{in } Q, \\
v^*.n = 0, \quad \mathrm{curl}\, v^* = v^*\alpha(w) & \text{on } \Sigma, \\
v^*(t = T) = 0, & \text{in } \Omega, \\
 & \\
-\dfrac{\partial h^*}{\partial t} - v.\nabla h^* - w.\nabla h^* - g\,\mathrm{div}\, v^* = 0, & \text{in } Q, \\
h^* = 0, & \text{on } \Sigma^+, \\
h^*(t = T) = 0, & \text{in } \Omega.
\end{array}
\right.
\tag{3.1}
$$

where $\big(v(x^j, t; w) + w(x^j) - u_{d_j}(t)\big) \otimes \delta(x - x^j)$ is the distribution defined by

$$
\psi \to \int_0^T \Big(v(x^j, t; w) + w(x^j) - u_{d_j}(t)\Big) \psi(x^j)\, dt\,.
$$

Using the properties of the adjoint operator, we obtain the following critical extremum condition, $\forall \theta \in L^2(0, T; W)$.

$$
\begin{aligned}
\Big\langle & \frac{\partial v^*}{\partial t} + v\,\mathrm{div} v^* + w\,\mathrm{div} v^* + \mathrm{curl}\, v\alpha(v^*) - Dv^* + \omega\alpha(v^*) \\
& - h^*\,\mathrm{grad}\, h + C^*\big(C(v+w) - u_d\big) + \varepsilon\Lambda_W w, \theta \Big\rangle = 0.
\end{aligned}
$$

where $C^*$ is the adjoint operator of the observity operator $C$.

## 4. Resolution method

The numerical method used for the resolution of the equations of the model and the adjoint equations is based on the Galerkin method. This method is mainly based on the utilization of a special basis. In this work, we use a special basis well adapted to our problem, whose some properties have been shown in Orenga (1992).

So as to determinate the minimum of $J(w)$, we use an iterative method. We write the critical extremum condition in this way

$$\begin{aligned}&\varepsilon(w,\theta)_{L^2(0,T;W)} + \langle w \operatorname{div} v^*, \theta\rangle + (Cw, C\theta)_{(L^2(\dot{u}))^m} = -(Cv - u_d, C\theta)_{(L^2(\dot{u}))^m}\\ &-\left\langle \frac{\partial v^*}{\partial t} + v \operatorname{div} v^* + \operatorname{curl} v\alpha(v^*) - Dv^* + \omega\alpha(v^*) - h^* \operatorname{grad} h, \theta \right\rangle_{L^2(0,T;W'),L^2(0,T;W)}\end{aligned} \tag{4.1}$$

The method consists in considering the right-hand of the equation (4.1) as a function of $w$ at the previous iteration (BOSSEUR–ORENGA, 1998).

The resolution of (4.1) requires the introduction of the operator $C^*$ ; in fact, we have

$$(Cw, C\theta)_{(L^2(\dot{u}))^m} = \langle C^* Cw, \theta\rangle$$

and

$$(Cv - u_d, C\theta)_{(L^2(\dot{u}))^m} = \langle C^*(Cv - u_d), \theta\rangle$$

Due to the difficulty to obtain a numerical characterization of the operator $C^*$, we propose a resolution method more adapted.

We suggest to solve the equation (4.1) with a variational approximation method by using a basis of functions of the space of control $W$. It has been shown in BOSSEUR–ORENGA (1998) that one can approach $w$ by $w_r \in L^2(0,T;W_r)$, where $W_r$ is the subset generated by the $r$ functions $\{\theta_i = \nabla\xi_i\}_{i=1}^r$ where $\xi_i$ is solution of the problem

$$\begin{cases}\Delta\xi_i = 0 & \text{in } \Omega\\ \xi_i = \psi_i & \text{on } \gamma_e\\ \dfrac{\partial\xi_i}{\partial n} = 0 & \text{on } \gamma_f\end{cases}$$

in which $\{\psi_i\}_{i=1}^\infty$ verifies $\int_\gamma \psi_i = 0, \forall i \in \dot{u}$ .

So, denoting by

$$f(v^*, h^*) = \frac{\partial v^*}{\partial t} + v \operatorname{div} v^* + \operatorname{curl} v\alpha(v^*) - Dv^* + \omega\alpha(v^*) - h^* \operatorname{grad} h,$$

$$w_r = \sum_{k=1}^r \mu_k \theta_k,$$

and with $i=1,\ldots,r$, equation (4.1) leads to

$$\sum_{k=1}^{r}\mu_k\left\{(\varepsilon+\operatorname{div}v^*)(\theta_k,\theta_i)+\sum_{j=1}^{m}\theta_k(x_j).\theta_i(x_j)\right\}=-\sum_{j=1}^{m}(v-u_d)(x_j).\theta_i(x_j)-(f(v^*,h^*),\theta_i)$$

(4.2)

## 5. NUMERICAL TREATMENT

We solve the shallow water problem with the Galerkin method by using a well adapted special basis (ORENGA, 1992). This basis is determined by finite elements method with the help of Modulef software (INRIA). When the domain is simply connected, it is determinate by solving the following scalar problems

$$(P_g)\begin{cases}-\Delta p_i=\lambda p_i & \text{in }\Omega\\ \operatorname{grad} p_i.n=0 & \text{on }\gamma\end{cases}\qquad (P_r)\begin{cases}-\Delta q_i=\mu q_i & \text{in }\Omega\\ q_i=0 & \text{on }\gamma\end{cases}$$

We use an Hermite type element with three degrees of freedom by nodes that allows us to obtain a numerical expression of $Lp_i$ and Curl $q_i$. The Galerkin method consist in searching an approximated solution $(u_N,h_N)$ under the form

$$u_N(x,t)=\sum_{i=1}^{n}a_i(t)\frac{\operatorname{grad}p_i(x)}{\sqrt{\lambda_i}}+\sum_{j=1}^{m}b_j(t)\frac{\operatorname{Curl}q_j(x)}{\sqrt{\mu_j}}+\sum_{k=1}^{p}c_k(t)\operatorname{Curl}r_k(x),$$

$$h_N(x,t)=\sum_{l=1}^{q}d_l(t)p_l(x).$$

By this way, we transform the initial partial differential equations system in an ordinary differential one, whose the unknowns $a_i$, $b_i$, $c_i$, $d_i$, are the projections of the solution of an approximated problem on the basis. The properties of the special basis allow to surmount the difficulties linked to the nonlinear terms.

Problem $(R)$, used in order to homogenize the shallow water problem, is as well solved with the help of Modulef software.

In order to construct numerically the basis of $W_r$, we solve the $r$ following scalar problems

$$\begin{cases}\Delta\xi_\alpha=0\\ \xi_\alpha(x_j,y_j)=\begin{cases}1 & \text{if } j=\alpha,(x_j,y_j)\in\gamma_e\\ 0 & \text{if } j\neq\alpha\end{cases}\\ \nabla\xi_\alpha.n(x_j,y_j)=0 & \text{if }(x_j,y_j)\in\gamma_f\end{cases}$$

The numerical resolution of these problems is, as previously, made by finite elements method with the help of Modulef software, using the same elements.

Finally, we thus obtain an ordinary partial differential equations system that can be solved by the implicit Adams method, initialized with the implicit Euler method.

Equation (4.2) appears as an algebraic system of $r$ equations, where the $r$ unknowns are the $\mu_k$ and $m$ represents the number of available measurements, $\{x_j,\ j=1,\ldots,m\}$. This matrix system $AX=B$, of unknowns

$$X = \begin{pmatrix} \mu_1 \\ \mu_2 \\ \vdots \\ \mu_r \end{pmatrix},$$

is then solved by the pivot de Gauss method.

Once known the values of coefficients $\mu_k$ $(k=1,\ldots,r)$, we reconstruct the approximated solution

$$w_r = \sum_{k=1}^{r} \mu_k \theta_k ,$$

which correspond to the approximated value of $w$ for the following iteration of the control algorithm.

In fact, we have to compute the new values of $v$, $h$, $v^*$, $h^*$, corresponding to this new value of $w_r$ and so on until numerical convergence of the method[15] (FIG. 5.1).

[15] The demonstration of the convergence is given, in the linear case, in BOSSEUR—ORENGA (1998).

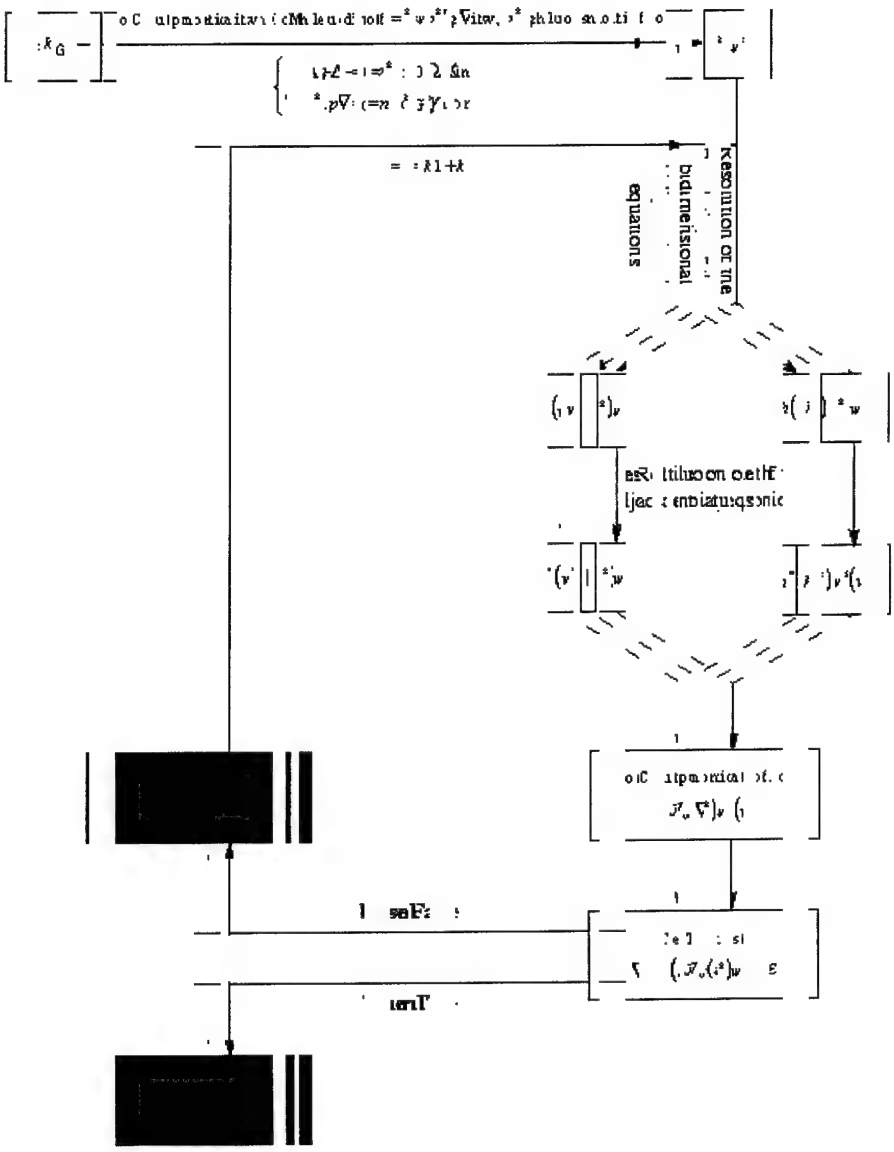

FIG. 5.1: *General scheme of the resolution*

## 6. NUMERICAL RESULTS

Now, we give a series of numerical results obtained for the bay of Calvi. The choice of this particular spot has been justified by the vicinity of the oceanographic research station STARESO which has permit the realization of many measurements campaigns; concurrently, numerical simulations has equally been executed by NORRO (1995). These results has been used here in order to reconstruct the boundary conditions in open sea.

The numerical method used being of iterative type, we had to set a starting value; for all the test presented here, the starting point is homogeneous boundary conditions.

Figure 6.1 represents a velocity field established from a numerical simulation executed by NORRO (1995) ; this last one has been used as the expected velocity.

In the first place, we have assumed this field to be given on half the node of the grid. The results obtained after 20 iterations of the control method are presented at figures 6.2. Figure $6.2_b$ representing the velocity corresponding to the $w$ obtained with the optimization method, points out a good adequation of the solution with the expected velocity, that is confirmed at figure $6.2_c$, where is presented the evolution of the relative error at measurements points

$$\eta_1 = \frac{\left\| u(x^j) - u_{dj} \right\|^2_{(L^2(\acute{u}))^m}}{\left\| u_{dj} \right\|^2_{(L^2(\acute{u}))^m}}.$$

Figures 6.3 represent the results obtained in considering the expected velocity known at one point out of twenty of the grid[16]. We can see on figure $6.3_b$ that the computed velocity does not correspond, in this case, to the expected field of the figure 6.1, that can be verified on figure $6.3_c$ in representing the evolution of the error $\eta_1$ with the number of iterations.

These remarks, as well as figure 6.4 where is presented the evolution of the $C^0$ error

$$\eta_2 = \sup \frac{\left| u(x^j) - u_{dj} \right|}{\left| u_{dj} \right|},$$

with the number of iterations, point out that under a minimum number of measurements points, the computed solution is no more in accordance with the expected field.

Lastly, we present at figure 6.5, a numerical result obtained in the nonlinear case. In the same conditions as in the case of figure 6.2, we can notice that the results are similar to those obtained in the linear case, that it is not astonishing because in several geophysical flow situations, the terms of Coriolis and pressure gradient are predominant.

[16] On the figure, the points of the grid where the velocity is known are represented by crosses.

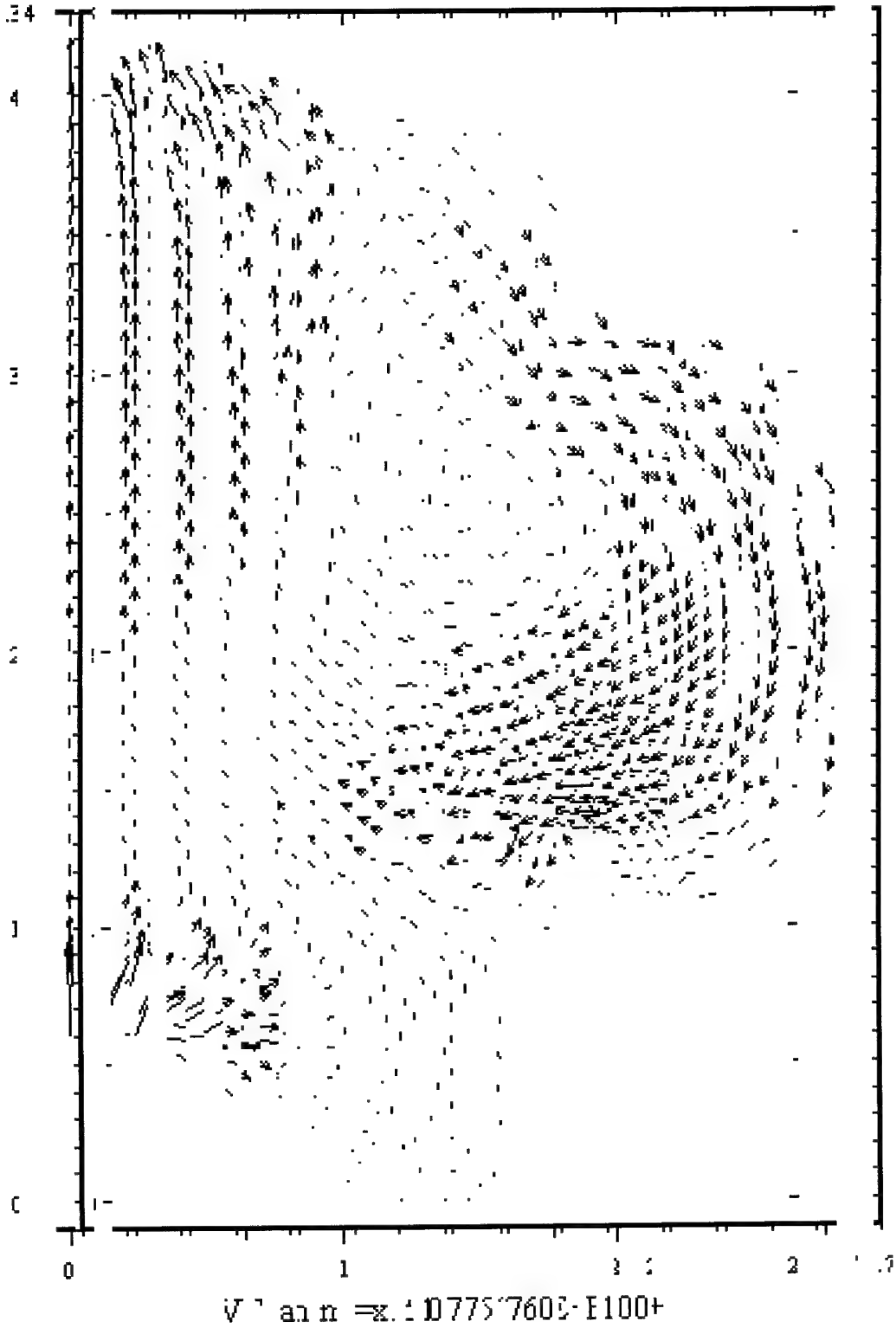


FIG. 6.1 : *Expected velocity*

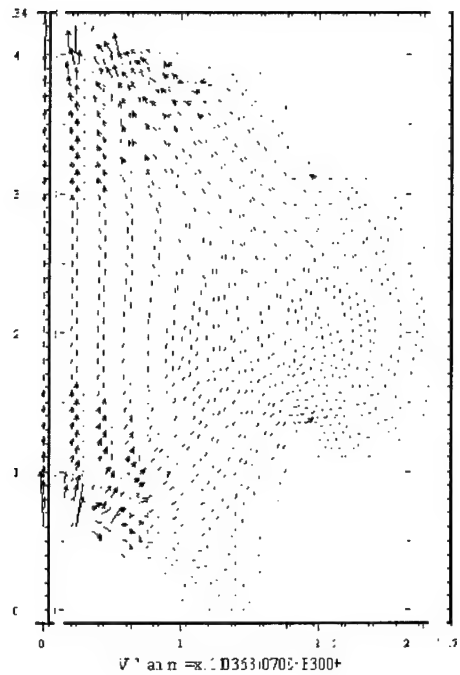

FIG. 6.2$_a$ : *w calculated assuming the velocity to be known at one point out of two.*

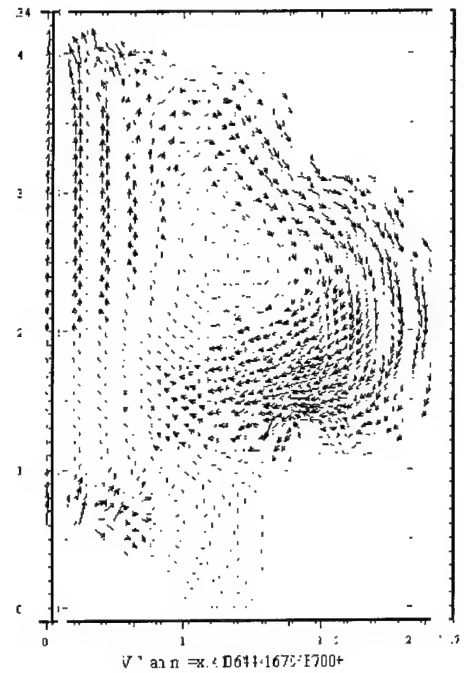

FIG. 6.2$_b$ : *Corresponding v velocity.*

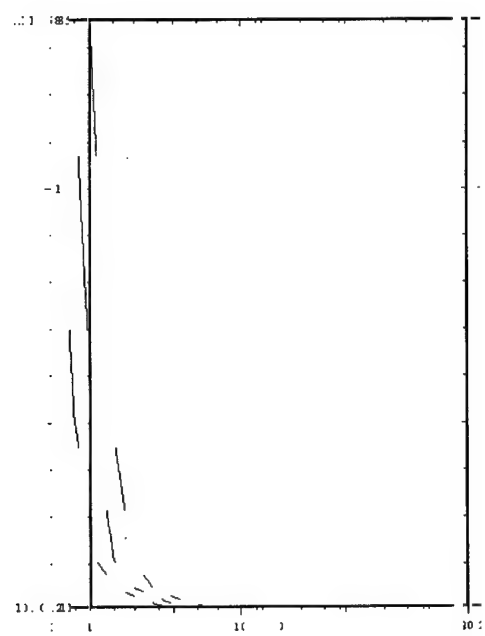

FIG. 6.2$_c$ : *Variations of the error*

$$\eta_1 = \frac{\left\| u(x^j) - u_{dj} \right\|^2_{(L^2(\acute{u}))^m}}{\left\| u_{dj} \right\|^2_{(L^2(\acute{u}))^m}}$$

*with the number of iterations.*

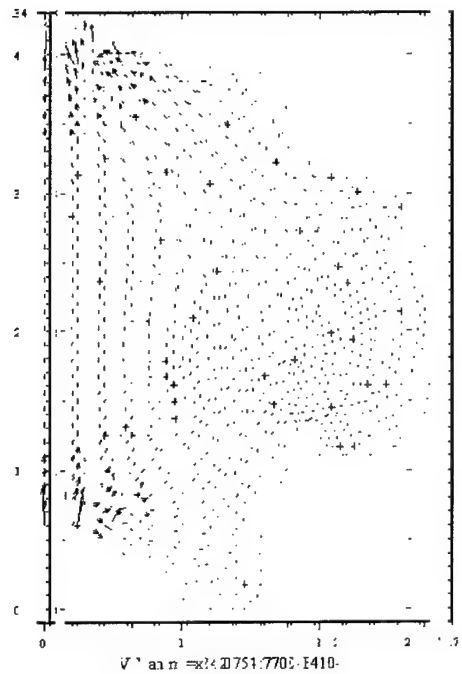

FIG. $6.3_a$ : *w calculated assuming the velocity to be known at one point out of twenty.*

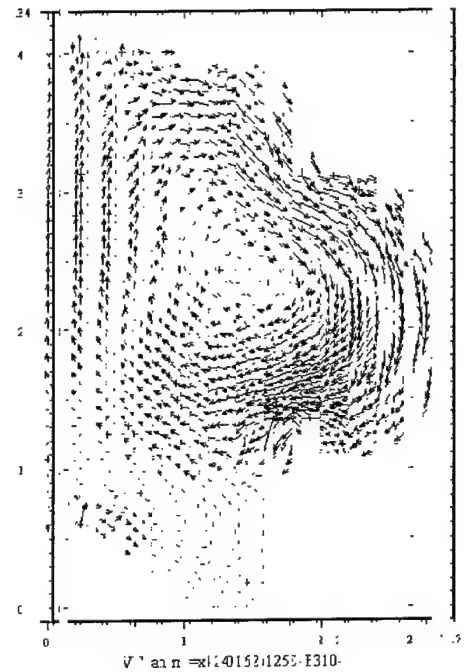

FIG. $6.3_b$ : *Corresponding v velocity.*

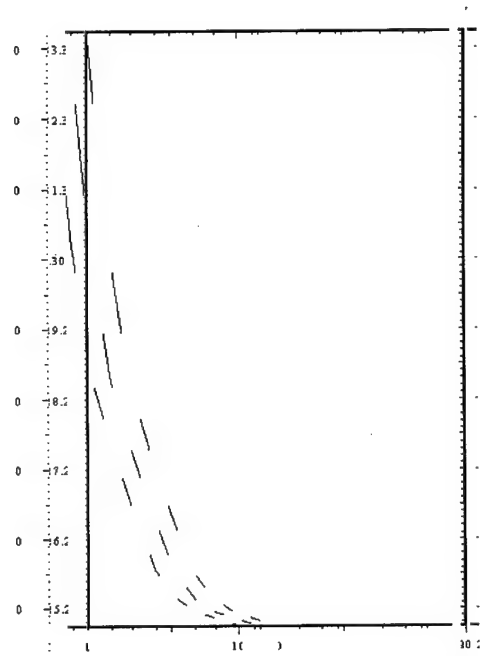

FIG. $6.3_c$ : *Variations of the error*

$$\eta_1 = \frac{\left\| u(x^j) - u_{dj} \right\|^2_{(L^2(\acute{u}))^m}}{\left\| u_{dj} \right\|^2_{(L^2(\acute{u}))^m}}$$

*with the number of iterations.*

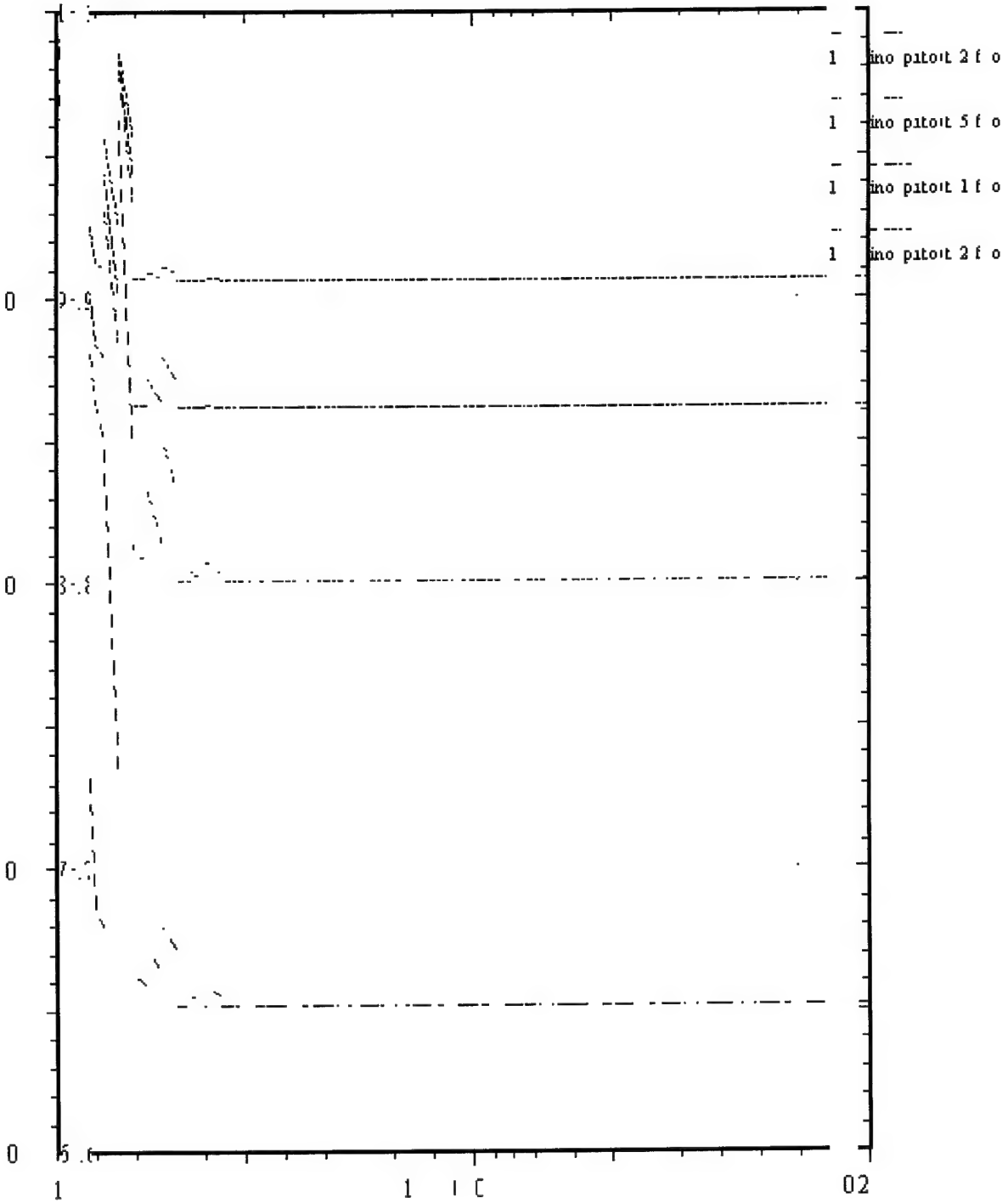


FIG. 6.4 : *Variations of the error*

$$\eta_2 = \sup \frac{\left|u(x^j) - u_{dj}\right|}{\left|u_{dj}\right|}$$

*with the number of iterations.*

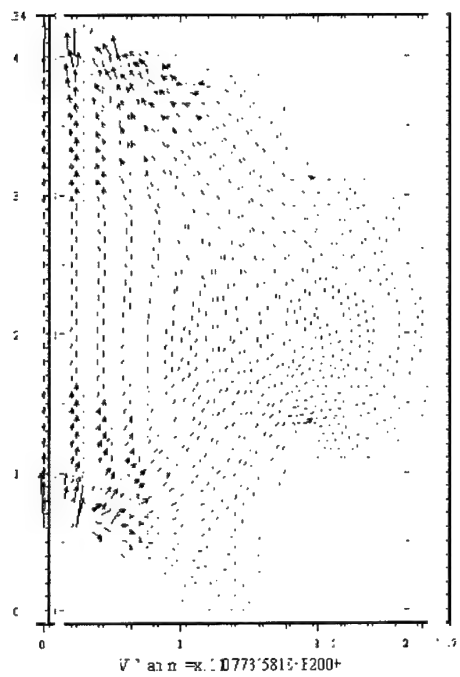

FIG. 6.5$_a$ : *w calculated assuming the velocity to be known at one point out of two (nonlinear case).*

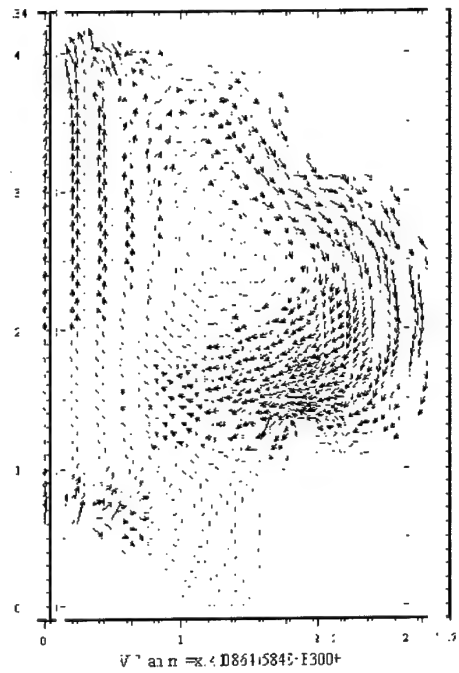

FIG. 6.5$_b$ : *Corresponding v velocity.*

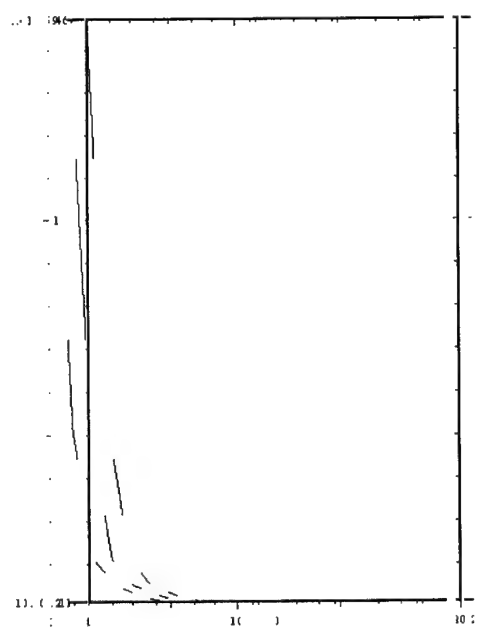

FIG. 6.5$_c$ : *Variations of the error*

$$\eta_1 = \frac{\left\| u(x^j) - u_{dj} \right\|^2_{(L^2(\acute{u}))^m}}{\left\| u_{dj} \right\|^2_{(L^2(\acute{u}))^m}}$$

*with the number of iterations.*

## 7. CONCLUSION

Our aim in this work was to implement a numerical method adapted to the determination of boundary conditions in open sea for a shallow water problem.

A first experience made on a square was proved to be encouraging. In particular, in this simplified case, it has been possible for us to reconstruct rather complex boundary conditions with a quite acceptable precision.

Besides, the Galerkin method is proved to be well adapted to the resolution of the adjoint equations as well as to the computation of the minimum of the functional, and permits to conserve reasonable time CPU.

In a second time, we have applied the method to a more realistic situation, representing the bay of Calvi. The results obtained in this case are equally proved to be encouraging.

Actually, we are working on an adaptation of the numerical method to a three dimensional model doing a control on the viscosity.

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# Early lifecycle considerations for COTS-Intensive systems

Ronald J. Kohl
Averstar, Inc.

## Early Lifecycle Considerations for COTS-intensive Systems

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Ronald J. Kohl,
AverStar, Inc.
kohl@averstar.com



## Agenda

- Engineering of Systems
- Using Commercial Off-The-Shelf Software
- Challenges and Issues Using COTS
- Necessary Skills When Using COTS
- Conclusions

## Engineering of Systems

- Process changes needed to make cost-effective use of COTS products:
  - **System requirements definition**
  - **Allocation of requirements to software**
  - **Selection of off-the-shelf SW**
- Leverage new technology, but use lessons learned, over the last 20-30 years, on how to engineer successful, supportable systems
- This talk addresses the impact of using COTS products on how systems engineering can and should be done



## Lessons Learned Engineering Systems

- Our understanding of how systems engineering can increase the prospects of software engineering success has evolved, for example:
  - Need for all requirements to be defined at the start of the software effort has evolved to identification of areas of uncertainty
    - spiral and incremental development
    - prototyping, rapid application development, etc.
  - Software now drives requirements allocation in many software-intensive systems
- System architecting of unprecedented systems recognized as a major challenge (first software implementation is probably throw-away*)

* As discussed in The Mythical Man-Month

## Lessons Learned Engineering Systems (cont'd)

- Having a System Operational Concept (how the system will fulfill the customer's needs) significantly increases successful implementations
- Having multiple views on the software/system (e.g. hierarchy of components and operational threads) increases likelihood of successful system integration and test
- Software involvement in system requirement definition, identification of derived requirements, and requirements allocation to hardware, software and personnel can reduce risks greatly



## Lessons Learned Engineering Systems (cont'd)

- Plan work based on what you know, and what you don't know but need to learn or discover
- Understand the extent of knowledge about:
  - **who the stakeholders are**
  - **the stakeholder's needs and constraints**
  - **the application domain**
  - **the system ops concept; the software ops concept**
  - **potentially applicable technologies available in the marketplace**
  - **your organization's existing (software) products**
  - **software development environment, tools and methods**
- Use data to confirm/illuminate this understanding
- View every software development as incremental
- Identify what needs to be discovered in each increment

## Commercial Off-The-Shelf SW

- How off-the-shelf software differs from hardware
- Software economics
- A bit of history
- Virtues of COTS
- Drawbacks of COTS software
- Models for using COTS SW
- Challenges of using COTS SW
- Human implications: skills required
- Conclusions on use of off-the-shelf software



## Difference Between HW & SW

- Hardware used to be special-build too
- Standards for power consumption, interfaces, etc. were put in place
- Catalogs were developed to disseminate information on what parts are available
- Hardware distribution allows each step in the value chain to garner revenue
- Software does not have the same economics

## Software Economics

- Software can be duplicated/distributed at costs so low that incentives to pay each member of the value chain are ineffective
- Make/buy comparisons are skewed by industry problems with inaccurate software cost estimation (optimism of developers)
- Economics of using COTS SW changes dramatically when a product's sales model changes (from hundreds of customers to thousands or millions)
- Rapid evolution of platforms and operating systems makes versions of a COTS package obsolete quickly



## Using Existing Software, Including Commercial Off-The Shelf SW

- In the 1970s and 1980s, software reuse was identified as a key strategy for reducing software costs
  - Japanese "software factory" approach
  - Design (architecting) for reuse
- In the 1990s object-oriented software makes integration of separately developed software components more feasible
- The software profession has gotten reusable components, but they don't meet industry criteria for appropriateness for reuse
  - Design for reuse "the right way" seems too expensive for commercial software developers, just as it was for system developers

## Virtues of Commercial Off The Shelf

- Development costs are lower than custom development, because product development costs are shared over many users
- Many others participate in finding bugs, limitations and Dormant Code in the product (and the producer may actually fix these bugs)
- You can incorporate new technology more quickly because you use products containing it without having to learn all about it yourself
- Development time and risk are avoided when the COTS product provides all the features you need



## Drawbacks of COTS Software

- Harmonization of a COTS package with
  - Platform-specific operating system variants and peripheral drivers
  - Operating system version(s)
  - Companion COTS SW packages
- Feature availability and timing (vaporware)
- Bug fixes often only available in later releases
- Difficult features dropped in later releases
- Features glut can swell resource requirements
- Unknown features (Dormant Code) can impact system
- Long-term support of COTS software
  - Vendor survival (escrowing source code)
  - Evolution of features

## Models of COTS SW Usage

- Subroutine library model
- One "anchor" COTS application model
  - Macro language to write your application
  - Other applications with built-in bindings to the anchor application
- Islands of COTS SW packages with minimal interfaces
- Disparate COTS packages as building blocks; glue code used to integrate them



## Challenges of Using COTS SW

- Using a SW package for what it is worth requires adopting the vendor's conceptual framework
  - May not match either user or developer's ideas about what the system should do or how it should do it
  - Documentation often does not explicitly describe this conceptual framework; some developers infer it from installation and operational manuals
- This conceptual framework governs:
  - How tasks are decomposed in the software
  - Interfaces (to user and other software/OS)
- Multiple COTS SW packages with different conceptual frameworks may be tough to integrate even if they interface well

## Which Comes First, the Chicken (Requirements) or the Egg (COTS SW)?

- Conventional system development principles include a purposeful sequence:
  - **Need identification (problem/opportunity identification)**
  - **Needs analysis**
  - **System requirements definition**
  - **Allocation of functions to hardware, software and personnel**
  - **Derivation of software requirements**
  - **Selection of applicable existing/COTS software**
- Effective use of COTS software generally requires COTS SW assessment starting during needs analysis
  - **Drives many system requirement definition specifics**
  - **Dictates functional allocation**
  - **Determines derived requirements allocated to COTS software**



## Impact of COTS SW on Developers

- Have you ever used COTS SW?
- Recall the impact of COTS usage has had on you, as
  - a user of the software's functions
  - an integrator of the software with other software and/or the processes you use to get your work done
  - you distinguish between features and bugs in the software

## Key Skills in Using COTS SW

- Different skills are needed for using COTS SW effectively
- Most COTS SW packages could be designed/ implemented better by your good people
- Designing and writing code is more fun for most software engineers than integrating the (sub-optimal) packages available off-the-shelf
- Integration skills are different than development skills
- Problem-resolution is different when you must work around limitations/characteristics of a COTS SW package



## Conclusions on Using COTS SW

- In the future, most software development efforts won't be able to afford not to use off-the-shelf software
- Used inappropriately, off-the-shelf software can cost more to use than developing needed software functionality from scratch
- Understanding what it takes to use COTS SW effectively is very important, so you can help your enterprise make the right business decisions

# Heuristics

- **Shop early, shop often**
- Try it before you buy it
- Take it for a test drive
- Kick the tires
- Know the vendor
- Know the marketplace
- Know your options
- **But buy only when you are fully informed**